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PROJECT EAGLE - PHASE I

BULK MUSTARD DEMILITARIZATION
AT
ROCKY MOUNTAIN ARSENAL
DENVER, CO

FINAL REPORT

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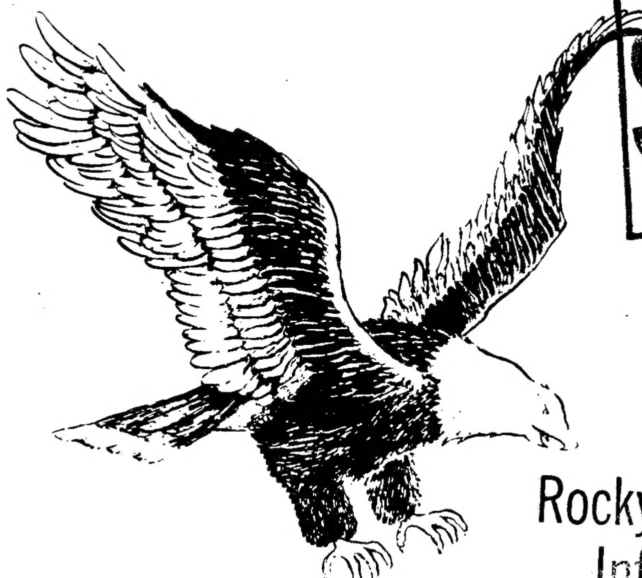

Rocky Mountain Arsenal
Information Center
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DECEMBER 1975

OFFICE OF THE DA PROJECT MANAGER
FOR
CHEMICAL DEMILITARIZATION AND INSTALLATION RESTORATION
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THIS REPORT COVERS THE DEMILITARIZATION OF EXCESS STOCKS OF THE TOXIC AGENT MUSTARD AT RMA. THIS REPORT DETAILS THE EXPERIENCE GAINED IN THIS PROGRAM AND SUMMARIZES SCHEDULE AND COST CHANGES. TWO TYPES OF BULK MUSTARD WERE INVOLVED IN THE DISPOSAL PROGRAM: H AND HD. THE DEMILITARIZATION OF MUSTARD STOCKS AT RMA WAS SUCCESSFULLY ACCOMPLISHED.

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DENVER, COLORADO 80240

FINAL REPORT

PROJECT EAGLE I BULK MUSTARD DEMILITARIZATION

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INTRODUCTION

This report has been prepared in detail to record all pertinent facets of the Mustard Demilitarization Program at Rocky Mountain Arsenal from the project's inception in October 1969 to July 1974.

For the reader's convenience, the document is sectionalized as follows:

Figures, tables, and a List of References relating to the text are presented in the rear of each section, as applicable.

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SECTION 1

SUMMARY AND CONCLUSIONS

1.1 SUMMARY

This report covers the demilitarization of excess stocks of the toxic agent Mustard at Rocky Mountain Arsenal (RMA) between October 1969 and July 1974. During this period of time the Department of Army decided to abandon possible sea burial of these excess stocks and develop a plan to demilitarize them at the site where they were stored. A Program Manager was established to manage this and other chemical demilitarization programs. Rocky Mountain Arsenal became the first installation where disposal of chemical stocks was planned, and the Mustard stocks were the first to be scheduled for disposal.

The initial plans for disposal of Mustard at RMA were developed in 1969 and budgeting, planning, scheduling and award of construction contracts occurred. The initial system for disposal and environmental control was labeled The Tailor System after its developer. An extensive engineering program was conducted under the direction of Edgewood Arsenal to define the design parameters that related to agent destruction, control of the environment, atmospheric monitoring, etc.

The initial system was delivered in June 1971 and final testing was undertaken. The final approval process continued to become increasingly complex because of environmental considerations and the wide breadth of interest in the program, and resulted in changing requirements the system was expected to meet. It became apparent early in 1972 that the Tailor System, as originally constituted, could not meet the desired production rates within the environmental constraints now defined. For this reason the program was redirected to utilize other furnaces and additional scrubbing equipment available in the Rocky Mountain Arsenal plants area. Once the final tests were completed and approvals received, the production effort began in August 1972 and continued at an improving production rate through the remainder of the program. There was a continual upgrading of the plant production capability and the pollution control equipment during the program. The burning of all liquid agent was completed in November 1973 and the decontamination of all containers completed by February 1974. Subsequently, a test program to support other demilitarization programs (Chemical Agent Munitions Disposal System) was conducted so that with the final cleanup of the plant, the final completion of the program was in August 1974.

This report details the experience gained in this program and summarizes schedule and cost changes.

1.2 CONCLUSIONS

The demilitarization of Mustard stocks at RMA was successfully accomplished. There were considerable cost increases and scheduled readjustments necessary because of technical problems and changing requirements.

There was no water contamination emanating from this operation nor was there any lessening of the air quality as a result of the operation.

No serious exposures to personnel occurred during this program.

While the disposal of scrap, iron oxide and ash from this operation posed no problem, the final disposition of the salts remains to be determined; several courses including its use to stabilize land fills, possible burial or ocean disposal, all remain possible candidates for its final disposal.

This program proved valuable in developing the technology to support future demilitarization programs; it served as a pilot operation for many concepts relating to CAMDS.

The Mustard Demilitarization Program at Rocky Mountain Arsenal arrived at a successful conclusion through the joint efforts of many. The cooperation of federal agencies, state and local agencies, and private firms were necessary to achieve the goal. The local news media publicized the program's problems with schedules and the program successes. The program, on the whole, demonstrated the cooperation of the engineering agency at Edgewood Arsenal and RMA under the direction of the Program Manager's Office to achieve the final result.

SECTION 2

BACKGROUND

2.1 GENERAL

Two types of bulk mustard were involved in the disposal program at Rocky Mountain Arsenal; they are identified as H and HD mustard. Type H mustard was made by the Levinstein process, and contains as much as 30 percent impurities by weight, which tend to settle out when stored. These impurities are chiefly sulfur, organosulfurchlorides and polysulfides. Type HD mustard has been purified; it is relatively free of organic impurities and is almost pure 2,2' dichlorodiethyl sulfide. Iron oxide corrosion products occur in both types of mustard.

2.2 HISTORY OF THE AGENT AT RMA

2.2.1 PRODUCTION AND REDISTILLATION

In 1939, an expansion of the U.S. mustard production facilities was required to meet desired stockpile requirements; new plants were established at Huntsville, Alabama, and subsequently augmented by facilities at Rocky Mountain Arsenal, Pine Bluff Arsenal, and Edgewood Arsenal. The Levinstein process for production of mustard was selected for these plants after considering alternate plant designs, costs, and availability of raw materials.[1]

During the 1942-1944 period, mustard agent was producted at the above plants, using the Levinstein process; this process is essentially the reaction of ethylene with sulfur monochloride and yields mustard agent and free sulfur. The reaction can be shown as:

$$S_2Cl_2 + 2\,CH_2 = CH_2 \longrightarrow S\begin{matrix} \diagup CH_2\text{-}CH_2Cl \\ \diagdown CH_2\text{-}CH_2Cl \end{matrix} \quad +S$$

The sulfur, which initially combines with the mustard agent, separated out when stored. Freshly prepared Levinstein mustard contained approximately 68 to 70 percent mustard agent. During storage, however, the Levinstein mustard (H) in unprotected steel munitions or storage containers becomes markedly deteriorated and unstable.[2] With its polysulfide content, the Levenstein mustard attacked the steel; the loosely-held sulfur oxidized the iron to ferrous sulfide, which then dissolves in the sulfonium salts that were present.[3]

It was evident that the deleterious impurities of the Levinstein mustard should be removed. The process for removal included washing with water, drying, and vacuum distillation. The product, distilled mustard, or HD, contains about 92 to 95 percent mustard agent, and is much more stable than the Levinstein mustard.

By 1944, the distilled mustard (HD) was classified as the standard agent, and the Levenstein mustard (H) was reclassified as a substitute standard.[4] "By standardizing HD, existing stocks of deteriorated Levinstein H could be converted to the more stable HD, immediately usable when drawn upon. Moreover, at the end of the war it would be economically unsound to be saddled with large stores of unstable mustard. To destroy the material would be wasteful, yet surveillance and gradual disposal of deteriorating stores might cost even more. HD stocks, on the other hand, could be retained in postwar reserves."[5] This reasoning eventually led to the transfer of all bulk Levinstein mustard stocks to Rocky Mountain Arsenal, where it was to be distilled into HD during 1945 and 1946. The distilled mustard (HD) was to be put into ton cylinders for stockpile retention.

2.2.2 DEMILITARIZATION AND STORAGE

During the 1947 to 1950 period, obsolete and deteriorating 155MM, 105MM and 75MM shells filled with undistilled Levinstein mustard (H) were demilitarized at RMA. The agent drained from these shells was put into ton containers for storage until it could be upgraded by distillation to HD; however, the upgrading did not occur, because the course of other events limited the need for this agent.

2.3 DISPOSAL PLANNING

2.3.1 EARLY MUSTARD DISPOSAL PLANS

Late in 1968, a survey of toxic material storage in depots and storage areas revealed that disposal of certain munitions and bulk agents would purge the stockpile of obsolete, excess, and unserviceable chemical munitions and/or bulk agent. Further, an undesirable situation had developed at Rocky Mountain Arsenal, near Denver, Colorado, where recent airport expansion, industrial development, and population growth were encroaching on the west and south edges of the Arsenal. Political considerations and the hazards of a possible accident led to the decision to remove munitions and agents from the Denver area.[6]

A number of disposal methods were studied including: demilitarization of munitions and burning or chemical neutralization of the agents; land burial; and sea burial. The choice of sea burial over the other methods was selected based upon considerations of safety: environmental contamination, time and cost.[7] Sea burial required loading the material aboard an excess cargo hulk, towing it out to sea and scuttling in approximately 1200 fathoms (7200 feet) of water.

One of the excess items in the stockpile was the ton containers filled with bulk mustard (H and HD). The decision to dispose of these stocks in sea burial operations was made in May 1969 with the US Navy conducting the operation. At that time, twelve similar disposal actions had been accomplished, three of which involved chemical materials: 19 June 1967, 19 June 1968, and 7 August 1968. The Navy referred to this program of disposal at sea as Operation CHASE (Navy acronym for "Cut Holes And Sink Em"). It was thought to be the fastest and safest way of disposing the hazardous material.

The bulk mustard agent stockpile at RMA in 1969, is shown in Table 2–1. As a result of a reevaluation of the mustard agent requirements at that time, the RMA bulk mustard stockpile was determined to be excess and therefore designated for disposal.[6]

	LEVINSTEIN (H)	DISTILLED (HD)	TOTAL
One Ton Containers	2,456	951	3,407
Equivalent Tons of Agent	2,214	857	3,071
Equivalent Gallons of Agent	420,000	164,000	584,000

TABLE 2–1. BULK MUSTARD AGENT STOCKS AT RMA, 1969

As objections to the Army's plans for sea disposal developed, objections were voiced by several Congressmen, led by Rep. Richard D. McCarthy of New York. The Congressmen were concerned with the hazards to the public during shipment of the material to the East Coast dock sites and with the possible ecological impact of contamination of the ocean that might affect marine life at the burial site. As a result of these concerns, and with others relating to the nerve agents included in Operation CHASE, the Department of Defense announced that the shipments would be suspended, pending a review by the National Academy of Sciences.

2.3.2 NATIONAL ACADEMY OF SCIENCES REVIEW

An Ad Hoc Advisory Committee was appointed by Frederick Seitz, the President of the National Academy of Sciences (NAS), in response to a request on 14 May 1969 from Dr. J.S. Foster, Jr., Director of Defense Research and Engineering, Department of Defense, "for an assessment of hazards involved in the execution of 'Operation CHASE' (and alternate plans) for the disposal of certain surplus chemical warfare stocks of the US Army".[8]

The members of the NAS Ad Hoc Committee were selected to bring a broad range of relevant scientific and engineering expertise to bear on this matter, including chemistry, biology, toxicology, physiology, and oceanography, as well as practical experience in manufacture, handling, transportation, and disposal of hazardous materials, including explosives and chemical warfare agents.

The Committee, under the chairmanship of Dr. G.B. Kistiakowsky, Professor of Chemistry at Harvard University, recognized that eventual disposal hazards of the mustard, intended for the 1969 Operation CHASE, would continue to exist without positive action. They also felt that "the Government should set an example to private organizations and individuals of minimizing risks to humans and damage to the environment, even though this may complicate and make more costly its own operations." Therefore, NAS recommended that Operation CHASE, as originally conceived, be modified. They addressed their comments to five types of chemical materials, one of which was the bulk containers of mustard at RMA.

Their discussion of the bulk mustard developed that:

"The transportation of these heavy steel containers by rail should be considered a hazardous operation subject to safety precautions practiced by the Army. However, we consider that such transportation of an almost nonvolatile liquid (Mustard H or HD) would involve virtually no hazards of a catastrophic accident because even a strong fire would not rupture the tanks and boil off the mustard. Hence, the safety and security plans adopted by the Army to deal with accidents resulting in minor leaks and even larger local contamination are adequate. Similarly, we can conceive of no likely *catastrophic* accidents occurring during the towing of a CHASE ship to the disposal area.

"In the past, various chemical warfare agents have been repeatedly disposed of in the oceans by the United States and other nations (see, for instance, House of Commons Parliamentary Debates, Weekly Hansard, No. 484, 25 March - 31 March 1960). We have no information regarding possible deleterious effects of these operations on the ecosystem of the seas.

"Most of the one-ton containers of mustard would probably not rupture upon the bottom impact of the sinking CHASE ship. However, their brass valves (forming an electrochemical couple) would cause moderately rapid corrosion of the steel containers, so that large numbers of cylindrical shapes of solid mustard weighing about a ton each would eventually be exposed to sea water on the bottom. Considering the very slow rate of solution of solid mustard in sea water at 3.5°C, the rate of its hydrolysis (and hence detoxification), and the effects of dissolved mustard on fresh-water fish, we believe that the ocean volume made lethal to fish would, in all probability, be extremely small, although some pollution would continue for years. We are concerned, however, about the effects of mustard on the germ cells of fish and on unicellular and larval organisms, concerning which no quantitative data were available. Thus, the effects of these large masses of mustard on the oceanic ecosystem are not predictable.

"Mustard is readily combustible and, in the past, about 3,000 tons of it have been destroyed by burning in a special furnace at the RMA.

"Some of the products of combustion are air pollutants of the same type as those released in some industrial and electric-power-generating activities, namely hydrogen chloride and sulfur dioxide, and none have properties of chemical warfare agents."

As a result of their study, NAS recommended that:

"The mustard scheduled for disposal in CHASE (and about 6,600 tons more in the 7,332 containers still to be disposed of, as mentioned previously) be burned in government establishments where storage is safe and local air pollution from the resulting SO_2 and HCl is not a serious problem. This procedure was successfully followed at RMA in an incinerator having a heat dissipation capacity of about $17(10)^6$ BTU/hr. The products of combustion were dispersed into the air from a

200-foot chimney. Should maximum ground-level concentrations of pollutants prove to be excessive, a simple liquid scrubber should be added to the existing facilities and the effluent sent to the sealed lake. If for compelling reasons, the disposal is at a site other than RMA, similar facilities are suggested, with thought being given, during design, to long-term use to incinerate other materials."

REFERENCES

[1]Letter to RMA, CMLET-C, Subject: (Project E7a-1 Job 9) "Recommendations on Mustard", dated 3 Jan 1974.

[2]Chemical Corps Board Study 6-52, "H vs HD vs TGH", 22 Jan 1953, approved 6 May 1953.

[3]Letter to RMA, CMLET-C, "Recommendations on Mustard".

[4]CWTC Item 1049, Standardization of Persistent Agent, HD, dated 10 June 1944 and approved by item 1094, same subject, dated 7 Jul 1944.

[5]Cml Corps Board Study 6-52, p. 1.

[6]Letter to RMA, AMCMR-DS, subject: Disposition of U.S. Stockpile of Mustard Agent and Munitions, dated 23 Feb 1969.

[7]Statement by Mr. Charles L. Poor, Acting Assistant Secretary of the Army (Research and Development) to the 91st Congress on 13 May 1969.

[8]"Report of the Disposal Hazards of Certain Chemical Warfare Agents and Munitions", prepared by an Ad Hoc Advisory Committee of the National Academy of Sciences, 24 Jun 1969.

SECTION 3

INITIAL SYSTEM DEVELOPMENT AND TESTING

3.1 MUCOM AD HOC COMMITTEE

In response to the recommendation of the National Academy of Sciences, Department of Defense (DOD) completely abandoned the proposed sea burial of bulk mustard agent of Operation CHASE. Preliminary plans and procedures were then developed for disposal of the 2456 ton containers (2214 tons) of Levinstein mustard (H) and the 951 ton containers (857 tons) of distilled mustard (HD) by burning in existing and proposed facilities at Rocky Mountain Arsenal. On 24 July 1969, the Commanding General of US Army Munitions Command (MUCOM), established an Ad Hoc Committee to review and evaluate the demilitarization and disposal program at RMA to ensure that the program conformed with the recommendations of the National Academy of Sciences.[1]

The MUCOM Ad Hoc Committee determined that the preliminary procedures and concepts considered by RMA for the detoxification of the bulk mustard agent were not adequate to permit initiation of the disposal operations. Furthermore, the Committee recommended postponement of the incineration until pollution baseline and stack effluent data were obtained and permanent monitoring sites were established.[2]

3.2 THE ESTABLISHMENT OF TASK FORCE EAGLE ORGANIZATION

As a result of the critical review by the MUCOM Ad Hoc Committee, a twelve-man task force team was assembled to deal with both the bulk mustard and the M34 GB cluster demilitarization operations at RMA. This team was headed by Lieutenant Colonel Sampson H. Bass, Jr. and was designated Task Force Eagle (TFE). Membership of the organization consisted of representatives from the Army Environmental Hygiene Agency (USAEHA) (pollution control), Rocky Mountain Arsenal (operations), and Edgewood Arsenal (management, engineering, research, safety, technical escort, and finance). TFE was to plan and establish a capability to demilitarize, detoxify, and incinerate mustard-filled ton containers and the M34 GB munition located at RMA. The following guidelines were provided to TFE:

A. "The basic guiding principle will be absolute safety and security rather than cost or time.

B. "Maximum protection will be provided for operating personnel.

C. "There must be absolute assurance that toxic agent released from any possible accident during the demilitarization, detoxification, incineration operations will be totally contained.

D. "All aspects of the operation must be justifiable from a personnel safety, security and community safeguard standpoint with sufficient hard data so as to be incontrovertible in the event the procedures, facilities, and concepts of operations are challenged in an objective evaluation of the program."[3]

The first program review meeting of Task Force Eagle was held 13 August 1969. Task or problem areas were established and the primary responsibility for each of them was assigned. The original problem areas and primary responsibilities associated with the mustard disposal program were defined as:

	PROBLEM AREA	RESPONSIBLE ELEMENT
1-1	Air quality at RMA	USAEHA
1-2	Emission limits	USAEHA
1-3	Shell Co. operations	RMA
1-4	Air monitoring during operations	RMA
2-1	Mustard disposal	Cml Lab, EA
2-2	Transportation	RMA
2-3	Transfer to burning	RMA
2-4	Incineration/scrubbing	Cml Proc Lab. EA
2-5	Combustion studies	Rsch Lab, EA
2-6	Sale of mustard	Prog Readiness Oper Ofc, EA
2-7	Safety	Safety, EA
2-8	Funding	Comptroller, EA
2-9	Scheduling	Tech Spt, EA
2-10	Other methods of disposal	Cml Proc Lab, EA

These "problem areas" became agenda items for follow-up review meetings which were held at approximate two-week intervals through 1971. The responsible elements submitted written reports and outlined their progress and problems during these regular meetings.

The major tasks facing the task group were (1) the preparation of a scope of work for the incinerator/scrubber procurement, (2) the establishment of an air quality baseline survey of RMA, and (3) the development of a detailed step-by-step mustard disposal operation plan.

3.3 TAILOR SYSTEM

To accomplish the first major task, chemical process engineers at Edgewood Arsenal, on 19 September 1969, provided the contracting officers with a scope of work describing incinerator/scrubber requirements. On 29 September 1969, requests for proposals were issued to sixty-two firms. After some difficulty concerning financial responsibility, the proposal of Tailor & Company, Inc., was found responsive to the technical requirements and a contract was awarded on 11 February 1960. The contractor was required to design, fabricate and install an incinerator/scrubber system, and a spent effluents drying system at RMA. The two systems were to operate as one complete incineration system. The contract required that the

equipment be installed and that component and subsystem testing be completed by 9 September 1970. After several delays due to design modifications and equipment delivery, the plant was considered complete and agent simulant tests were started in June 1971.

Between June and December 1971, several test runs were conducted, first with mustard simulant and then with live agent. For many reasons, the system never operated in the desired manner. It should be noted that, after contract award, there were two major categories of changes imposed on the incineration system. The first category of changes resulted from the unanticipated and objectionable corrosive/erosive effect of iron oxide mixed in the combustion products. The second category of changes resulted from more stringent emission standards imposed on RMA by Federal and State environmental regulations. The initial pilot tests demonstrated that to convert mustard to harmless byproducts, within the restrictive environmental standards, was a difficult technical challenge. Consequently, a special process engineering team was established at Edgewood Arsenal. This team developed formal process and equipment testing plans to determine the performance of existing equipment and to study alternate equipment and process techniques. These tests and their results are detailed in Appendix A.

The Tailor System did not survive the series of tests described in Appendix A. There was no economic or schedule advantage in renovating the Tailor System; this led to the decision to abandon the Tailor System process and instead dispose of the bulk mustard in the ton container furnace system at RMA.

3.4 DISPOSAL PLAN APPROVALS

When the mustard disposal program was originally developed in 1969, a relatively simple approval route was necessary. The usual Army approvals for toxic movement and disposal plants had to be obtained for such items as a site plan, a safety submission, and operating procedures. To this was added a comprehensive review of the mustard disposal plan by the special MUCOM Ad Hoc Committee, to ensure that the recommendations made by the National Academy of Sciences were followed. The procedures for the demilitarization of mustard agent were developed and outlined in the initial disposal plan, dated 5 October 1969. This plan was modified by the second report of the Ad Hoc Committee, dated 6 to 8 October 1969 and approved by the Department of the Army.

As this plan was being put into action, several new Federal laws and regulations were enacted which complicated the approval route. The demilitarization of lethal chemical and biological munitions and agents and the cleanup of facilities and grounds supporting such operations became rigidly controlled by Public Laws 91-121, 91-441 and 91-190.

The latter law, known as the National Environmental Policy Act, required filing an environmental impact statement with the President's Council on Environmental Quality (CEQ) (established by PL 91-190) and notification of Congress prior to initiation of demilitarization operations. Furthermore, PL 91-121 and PL 91-441 required that all movements and demil plans involving lethal chemical agents be

reviewed by the Surgeon General of the Public Health Service, Department of Health, Education and Welfare.

Therefore, on 7 April 1971, a draft environmental impact statement was distributed to Federal, State and local agencies for their review. Their comments and additional clarifications by the disposal team were incorporated into the final statement provided to the CEQ in June 1971. The Surgeon General of EPA conditionally concurred in the plans, pending verification of emission rates during the pilot runs. Letters to the President of the Senate and the Speaker of the House providing the required 30 days advance notification were dispatched during May 1971. Approval to start operating the incinerator/pollution control system and the liquid effluent drying system with mustard agent was received. The initial testing of the mustard disposal plant commenced with live agent on 12 July 1971.

A national press conference concerning the mustard disposal program was held at Rocky Mountain Arsenal on 20 July 1971, during which full-scale disposal operations were announced as beginning in late August of that year. The initial testing, however, revealed major system problems which required equipment modifications. Full-scale operations were postponed as a result of these, and subsequent pilot tests. The testing continued for approximately one year, during which the mustard disposal process was revised to include bulk agent incineration in the modified ton container furnaces. The tests were finally concluded with the preproduction tests in June 1972.

The preproduction tests included the safety review survey and the plant emissions tests, which were observed by Federal and State officials. A Senior Advisory Panel also examined the revised process. This panel, composed of technical experts, was established by Army Materiel Command (AMC) to review technical approaches and engineering designs pertinent to all chemical demilitarization programs.

The MUCOM Ad Hoc Committee originally established in July 1969, reconvened at Rocky Mountain Arsenal on 11 to 13 July 1972 to review and rigorously assess the final plans and facilities for disposing of the bulk mustard agent in ton containers. Other observers and consultants to this meeting included representatives of the Senior Advisory Panel, the EPA's Surgeon General's Office, the Regional Environmental Protection Agency Office, the USAEHA and the DOD Explosives Safety Board (DDESB). The personnel of the mustard disposal program team presented technical and management data relevant to the revised plan.

As a result of the comprehensive review of the step-by-step procedures and facilities, the Ad Hoc Committee concluded that the plans (with some minor changes) were adequate. The Committee stated that the proposed operation would "provide for a safe and effective method for disposing of bulk mustard at a nominal rate of one gallon per minute and meet all the previously furnished criteria and, with the exception of plume opacity, all established standards for conducting a production operation."[4] Therefore, the Committee recommended commencement of limited production at Rocky Mountain Arsenal for the disposal of bulk mustard agent.

The revised plan and safety submission, as modified by the Ad Hoc Committee, was then submitted to and approved by the Surgeon General of the U.S. Public Health Service, HEW and to the Chairman of the DOD Explosive Safety Board. Since the revised plan did not change any environmental considerations, personnel health requirements or emission standards, the environmental impact statement already on file with the Council of Environmental Quality was sufficient and no further approvals were required before startup of the disposal operations at Rocky Mountain Arsenal.

3.5 WASTEWATER DISPOSAL

The National Academy of Sciences, in making the decision to dispose of agent at RMA by incineration, had recognized that it had previously been done before at the Arsenal and further addressed themselves to the wastewater that would be generated in the process. They recommended the waterwaste products be discharged into Basin F, an existing sealed industrial waste basin. They also considered that the addition of these wastewaters to the sealed pond on the Arsenal would not be an issue as it would be a small increment of similar waste already in the pond.

The Army Staff, specifically MUCOM, took the NAS recommendations and developed a study dealing with the integrity of the membrane in Basin F. The MUCOM study concluded that while there was no outward appearance, based on monitoring of wells around the basin, of any leakage, the integrity of the membrane must remain suspect. As a result of this study, Task Force Eagle was directed to select alternate ways of disposing of the waste material other than Basin F. TFE looked at several alternatives, such as:

A. Construction of evaporative tanks (stainless steel).

B. Design and fabrication of an evaporative spray dryer.

C. Construction of additional basins similar to Basin F lined with more durable material and compartmented to allow drainage and repair of a given compartment, in event a leak should occur.

MUCOM approved a plan from TFE and forwarded it to DA, recommending construction of two 10-acre basins to handle all wastewater from the demilitarization projects at RMA. DA forwarded the plan to HEW and DDESB for comment. Both HEW and DDESB expressed reservations on the technical approach in building ponds and when the comments were returned, DA directed by letter from CBR Directorate of ACSFDR to drop plans for building ponds and develop, instead, a spray dryer system. This direction led to a contract with Bowen Engineering Company for two systems (GB and HD), capable of handling 30 GPM of liquid wastewater.

REFERENCES

[1]Message AMSMU-CG, 291530Z July 1969, subject: "Ad Hoc Committee on Review of RMA Chemical Demil Procedures".

[2]Report of the Ad Hoc Committee on the Review of Rocky Mountain Arsenal Demilitarization, "Detoxification and Burning Procedures for the M34 GB Nerve Gas Cluster and the One-Ton Containers of Mustard Gas", 1 Aug 1969.

[3]USAMUCOM Message, 071915Z Aug 1969, subject: "Demilitarization Operations at Rocky Mountain Arsenal".

[4]Third Report of the Ad Hoc Committee on the Review of Rocky Mountain Arsenal Demilitarization and Disposal Procedure for One-Ton Containers of Mustard Agent, dated 11-13 Jul 1972.

SECTION 4

FINAL SYSTEM DEVELOPMENT AND TESTING

4.1 CHANGEOVER TO THE TON CONTAINER FURNACE SYSTEM

4.1.1 ALTERNATES

Results obtained from the series of operational tests on the Tailor System indicated that the system might not meet the 3-gallon per minute (GPM) design incineration rate, within the emission requirements given in the Environmental Impact Statement. A recommendation was forwarded on 24 November 1971 from Rocky Mountain Arsenal to Edgewood Arsenal,[1] which called for initiation of action to obtain an alternate method of bulk mustard disposal using agent nozzles in the Building 538 ton container furnaces. This alternate approach was originally envisioned as a stopgap measure to begin the mustard demilitarization operation while the already extended Tailor System shakedown continued. The feasibility of a maximum disposal rate of one gallon per minute was agreed to by Task Force Eagle Mustard and Safety Representatives as well as US Army Environmental Hygiene Agency, Air Pollution Engineering Division; however, the recommendation was not favorably considered by the Director of Manufacturing Technology, Edgewood Arsenal, MD[2] on 7 December 1971, because of the unproven capability of the ton container furnace to burn mustard. It was recognized that it had sufficient merit to be considered as an alternative method as a backup to the Tailor system.

A meeting to evaluate the status of the Tailor disposal system was held during the week of 1 March 1972 and was attended by the Arsenal Commander.[3] The purpose of the meeting included consideration of alternate approaches including the ton container furnaces as the mustard bulk incinerators. The Tailor Reactor appeared capable of performing at the 3 GPM design rate; however, scrubber plugging problems associated with production of iron salts prevented the entire system from functioning as designed within the environmental constraints. A decision point for possible consideration of the ton container furnace to replace the Tailor System was established 15 April 1972 pending the results of a battery of additional tests. (The detailed objectives and results of these tests are contained in the Edgewood Arsenal Special Report by Mr. Lojek dated June 1974).

4.1.2 STUDIES AND TEST RUNS

When the approval to proceed with the concept of the ton container furnace bulk incinerator was requested of US Army Materiel Command (AMC) by US Army Munitions Command (MUCOM) on 29 March 1972, the request stated the opinion of MUCOM that the Environmental Impact Statement (EIS), previously approved for the Tailor system, need not be restaffed. It was felt that the new procedure did not represent a significant departure from the previously submitted EIS. The adaption of this interim program change was acknowledged to require revision of the approved Plan and Safety Submission. AMC approved the concept on 11 April 1972

pending the successful completion of the pilot studies described below. On 21 April 1972 the Department of the Army, Office Chief of Staff for Force Development concurred in the concept of the interim reduced rate, pending procurement of a new spray dryer and electrostatic precipitator, and agreed that the re-staffing of the EIS was unnecessary. The approval was sent to CG, USAMUCOM on 28 April 1972, along with the request for a revised plan and safety submission. The revised Safety Submission and Plan was submitted to MUCOM in June 1972 for approval.

The use of the two ton container furnaces for bulk agent incineration was explored in April and May 1972 and proved feasible. The spraying of agent through a furnace nozzle proved more desirable than the "dribble" method also considered, since it provided better combustion, less ash buildup in the furnace, and a higher feed rate (1.1 GPM versus 0.8 GPM respectively). The furnace temperature at this time was limited to 2100°F to prevent heat damage to the firebrick. Run A-10 was conducted from 19 to 22 May 1972, feeding mustard to both furnaces simultaneously. The maximum rate achieved was 2.0 GPM. The mustard emission limit of 0.03 gr/m^3 was not exceeded during the A-1 through A-10 test runs. Runs A-1 through A-9 were made without the benefit of the leased dry electrostatic precipitator.

Test Runs P-4 through P-9 were conducted utilizing a one bay dry electrostatic precipitator ("Dustmobile") leased from Precipitair Pollution Control, Longview, Texas. This piece of equipment was connected to the Tailor System for test runs during the 9 to 13 May 1972 period. Later for Runs P-4 through P-9, conducted from 22 May to 2 June 1972, it was utilized with the effluent gases from the Ton Container furnaces, operating at 1 GPM mustard feed. There were problems observed during operation of the "Dustmobile" in this mode. The primary problem was accumulation of condensate within the precipitator, causing electrical shorting. It was determined that the optimum operation of the precipitator was at a gas velocity of 4.5 feet per second, or 80 percent of the total furnace effluent; this entailed use of a bypass from the scrubber exit to the 200-foot stack to accommodate the excess effluent and resulted in an obvious reddish plume at the top of the 200-foot stack, as well as a reddish plume from the electrostatic precipitator (ESP) stack. The opacity exceeded the State's limit and therefore was a problem. It was temporarily helped by an agreement with the State of Colorado[5] designating the Mustard Operation as "an experimental operation, best described as an incinerator". This allowed operation for 142 operating days as a pilot phase, where the plume opacity could be 40 percent rather than the 20 percent required.[6]

Since one of the conclusions of the P-4 through P-9 test runs was that an improved dust collection system was required, the agreement with the State gave the necessary latitude to allow operations to commence. At a 20 April 1972 meeting at Edgewood Arsenal,[7] it was decided to commence operations. At this meeting the decision to abandon the Tailor system in favor of the ton container furnace disposal system was essentially complete.

Approval to proceed with the concept of the ton container furnace bulk incinerator was requested of CG, US Army Material Command by US Army Munitions

Command on 29 March 1972.[8] This request stated the opinion of MUCOM that the Environmental Impact Statement (EIS) previously approved for the Tailor system need not be restaffed since the new procedure did not represent a significant deviation from this previously submitted EIS. The adaption of the interim program change to the ton container furnaces was acknowledged to require revision of the approved Plan and Safety Submission. The concept was approved on 11 April 1972 by US Army Material Command[9] pending success of the pilot studies described above. Department of Army, Office of Chief of Staff for Force Development concurred in the concept of the interim reduced rate disposal procedure on 21 April, 1972,[10] pending procurement of a new spray dryer and electrostatic precipitator. Restaffing of the EIS was deemed unnecessary. The approval of the concept was sent to CG, USAMUCOM on 28 April 1974,[11] along with the request for a revised plan and safety submission. This revised Safety Submission and Plan was submitted to MUCOM in June 1972 for approval.

4.2 PREPRODUCTION OPERATIONS USING THE TON CONTAINER FURNACE SYSTEM

Two preproduction test runs were conducted in June 1972.[4] The first run, T-1, was conducted from 14 to 20 June to ensure that the ton container furnace system was ready for the simultaneous incineration of bulk mustard and the decontamination of the resulting empty ton containers without generating excessive pollutant emissions. Army Environmental Hygiene Agency (USAEHA) sampled the effluent gases from scrubber and ESP for mustard, particulates, NO_X, SO_X, acid mist and total acidity at various combinations of process conditions. Also the degree of split of the scrubber effluent stream to the 200-foot stack was studied in order to achieve the minimum overall plume opacity from the two exit stacks. Approximately 2,050 gallons of liquid mustard were incinerated at an average feed of 0.85 GPM. Five ton containers were burned with mustard residue weight ranging from 405 pounds to 705 pounds. The results of stack sampling showed negligible SO_X, very low levels of NO_X, acid mist and total acidity. Also mustard and particulate emissions were well within allowable limits.[12] Plume opacity readings of both the 200-foot and ESP stacks were marginally acceptable. A split of scrubber effluent of 80 percent to the precipitator and 20 percent to the 200-foot stack was recommended.

The second preproduction checkout test was Run T-2 (26 to 30 June 1972).[4] Its primary objective was to demonstrate the reliability and safety of the Mustard Demilitarization system, to verify the adequacy of the Standing Operating Procedures and to demonstrate that all pollution emissions were within the appropriate limits defined by the existing Colorado and Army Standards. USAEHA again took part in the test. The west furnace was used to incinerate bulk mustard introduced into the rear of the furnace through two atomizing nozzles. The east ton container furnace was used to decontaminate ton containers. The nominal agent feed rate was 1 GPM at a mixture of 2.5 parts H (Levinstein) mustard to 1 part HD (Distilled) mustard. The Levinstein mustard contained the bulk of the sludge, particulate matter and iron oxide.

Evaluation of effluent gas constituents was the same as in Run T-1. USAEHA personnel determined that, with the exception of the plume opacity (5 percent maximum), the emissions from the disposal operation did not violate the applicable standards. As a result of these test runs, USAEHA recommended[12] that pilot production operations commence according to the revised detoxification plan. The helpful approach taken by the State of Colorado greatly aided this recommendation.

4.3 APPROVAL OF THE TON CONTAINER SYSTEM

A preoperational safety survey of the mustard facility was conducted at RMA during the period 26 through 30 June 1972,[4] in accordance with Edgewood Arsenal Regulation SMUEA 385-7. The survey was made to evaluate the design and the installation of the mustard facility, the procedures, and the operations as they affected safety. The survey team was led by Mr. Leonard M. Lojek of the Edgewood Arsenal Demil/Disposal Office and included Mr. Neil H. Baker of the EA Safety Office, Mr. Bruce Chandler of the EA Product Assurance Office and CPT Hugh Stringer, Assistant for Demilitarization Operations at RMA.

The team followed the RMA standing operating procedures as well as a safety checklist and AMCR 385-1 (Safety Regulations for Chemical Agents H, HD, and HT) in evaluating the plant. In their assessment, the team emphasized: the degree of safety provided, the adequacy of the SOP for safety, and the effectiveness of production techniques and quality controls relative to safety.

As a result of the survey, the team concluded that: no safety deficiencies were serious enough to prevent production startup of the mustard disposal facility; the minor deficiencies found were immediately correctable; and additional training of the operation personnel was required to improve the understanding of their tasks and their proficiency in performing them.

As a result of the above, the Commanding Officer of EA forwarded the results of the preoperational safety survey and the USAEHA emission evaluation (described above) to CG USAMUCOM on 17 July 1972,[13] with the recommendation that the survey report be approved and that pilot scale operations commence; the start of full-scale operations was still dependent on receipt and installation of the new spray dryer and electrostatic precipitator, and approval of the June 1972 revised Safety Submission and Plan.

An examination of the revised process was also made by the Scientific Advisory Panel, chaired by Dr. Paul Gross.[4] This panel, composed of technical experts, was established by US Army Materiel Command to review technical approaches and engineering design pertinent to all chemical demilitarization programs.

The MUCOM AD/HOC Committee, originally established in July 1969, reconvened at RMA on 11 to 13 July 1972,[4] to review and rigorously assess the final plans and facilities for disposing of the bulk mustard agent in ton containers. Other observers and consultants to this meeting included representatives of the Scientific Advisory Panel, The Surgeon General's Office, the Regional Environmental Protection Agency

Office, USAEHA, and the DOD Explosive Safety Board. The personnel of the mustard disposal program team presented technical and management data relevant to the revised plan.

As a result of this comprehensive review of the step-by-step procedures and facilities, the AD/HOC Committee concluded that the plans, with some minor changes, were adequate. The committee stated that the proposed operations would "provide for a safe and effective method for disposing of bulk mustard at a nominal rate of one gallon per minute and meet all the previously furnished criteria and, with the exception of plume opacity, all established standards for conducting a production operation." Therefore, the committee recommended the commencement of limited production at RMA for the disposal of bulk mustard agent.[14] The revised plan and safety submission as modified by the AD/HOC Committee was then submitted to and approved by (1) the Surgeon General, Public Health Service (5 September 1972),[15] (2) the DOD Explosive Safety Board (4 August 1972),[16] and (3) Director, Chemical and Nuclear Operations, OACSFOR (11 September 1972).[17] There was an exchange of some additional information requested by DDESB; details are contained in the source documentation.[18] [19]

One additional requirement that resulted from the 11 to 13 July meeting of the MUCOM AD/HOC Committee was that the thaw room be challenged to insure agent containment. The thaw room had been evaluated by USAEHA in February 1971 from an air flow standpoint, but live agent was not used. The decision to use mustard agent resulted from the fact that no known simulant met the required sensitivity levels, and no presently known substance, other than mustard vapor, could give a reliable indication of the containment capability of the thaw room and the scrubbing capability of the charcoal filters. The test was conducted on 26 July 1972. It indicated that the mustard thaw room had satisfactory vapor integrity with the exception of the roof duct inclosure area. A further challenge was carried out after room modifications, with satisfactory results. A preliminary report was published by RMA Quality Assurance Office on 27 July 1972;[20] followed by a message report to CG, USAMUCOM on 3 August 1972,[21] in response to a message query received on 1 August 1972,[22] with a final report being forwarded to DDESB on 24 August 1972.[23]

REFERENCES

[1]RMA Letter: SMURM-DD, dated 24 Nov 1971 to EA, SMUEA-MT-E, subject: Alternate Method for Disposal of Mustard at Rocky Mountain Arsenal.

[2]First Indenture to RMA, dated 7 Dec 1971 to above.

[3]FOUO Talking Paper, subject: Results of Meeting with Col. Stoner, CO, EA, week of 1 Mar 1972.

[4]EA Special Report EASP, titled "Bulk Mustard Demilitarization at Rocky Mountain Arsenal April 1969 through September 1972", dated Jun 1974 by Mr. Leonard M. Lojek.

[5]Letter from State of Colorado to RMA, dated 19 Jun 1972, signed by Dr. Wood.

[6]RMA Travel Report, dated 13 Apr 1972 by Capt. Stringer to Georgia Institute of Technology.

[7]RMA Memo for Record, dated 24 Apr 1972 by Maj. E.S. Lipson, subject: "Rocky Mountain Arsenal Demilitarization Programs".

[8]MUCOM Letter, dated 29 Mar 1972 to AMC, subject: "Environmental Impact Statement for Mustard Demil at Rocky Mountain Arsenal".

[9]First Indenture to above, to HQDA (DAFD-CNS), dated 11 Apr 1972.

[10]Second Indenture to above, to AMC (AMCMV-VM), dated 21 Apr 1972.

[11]Third Indenture to above, to MUCOM (AMSMU-MS-CH), dated 28 Apr 1972.

[12]USAEHA Letter to EA, dated 7 Jul 1972, "Evaluation of Emissions from Bulk Mustard Operations, Rocky Mountain Arsenal, Denver, Colorado".

[13]EA Letter to MUCOM, dated 17 Jul 1972, subject: "Preoperational Survey of Mustard Disposal Facilities at Rocky Mountain Arsenal".

[14]"Third Report of the Ad Hoc Committee on the Review of Rocky Mountain Arsenal Demilitarization and Disposal Procedure for One-Ton Containers of Mustard Agent", dated 11-13 Jul 1972.

[15]HEW Letter to Assistant Secretary of Army, Mr. Mecum, dated 5 Sep 1972, no subject.

[16]DDESB Memo to Assistant Secretary of Army (I & L), dated 4 Aug 1972, subject: "Revised Safety Submission and Plan for the Detoxification Mustard and Detoxification of Empty Ton Containers at Rocky Mountain Arsenal, Colorado".

[17]DA, DAFD-CNC Letter to AMC (AMCSA-BC), dated 11 Sep 1972, subject: "Mustard Disposal at Rocky Mountain Arsenal".

[18]MUCOM, TWX to DA (DAFD-CNS), dated 7 Aug 1972, subject: same as above.

[19]RMA Letter to MUCOM (AMSMU-MS-CH), dated 28 Sep 1972, subject: "Response to Recommendations of Senior Advisory Panel".

[20]RMA, Quality Assurance Memo to CO, dated 27 Jul 1972, subject: "Special Test SOP, Test of the Total Containment of the Thaw Room".

[21]RMA, TWX, dated 2 Aug to MUCOM (AMSMU-MD-CH), subject: "Agent Containment Trial - Mustard Thaw Room".

[22]MUCOM, TWX, dated 1 Aug 1972 to RMA, subject: "Agent Containment Trial - Mustard Thaw Room".

[23]RMA (QA) Letter to DDESB, dated 24 Aug 1972, subject: "Agent Challenge of Mustard Thaw Room, Building 537", w/ RMA Test Report inclosed.

SECTION 5

OPERATIONAL PHASE

5.1 TRAINING OF PERSONNEL

Personnel training began on a one-shift basis on 18 July 1972. This training dealt with the operation of the "Dustmobile" and was given over a four-day period. One shift mustard incineration began on 27 July 1972.[1]

The first shift Engineer trained his shift during the period 27 July to 4 August 1972. This shift was subsequently sent to work in the clothing treatment plant, until required to start shift work on mustard disposal. The second shift started training on 7 August 1972 on day shift, completing its five-day, on-the-job training on 11 August 1972. The training of the third shift began on 14 August 1972, and was completed 18 August 1972. During the third shift training period the second shift was placed on the swing shift disposing of trash in ton container halves. The training of all three shifts consisted of on-the-job training in the Standing Operating Procedures and in the equipment operation. The short duration (five days) of this live agent training seems brief but it must be recognized that the work force cadre had been involved in the Tailor System shakedown, and the simultaneous testing operation of the ton container furnace system.

As a result of successful phasing in of the three shift crews, disposal operations began officially on a three-shift basis at 0735 hours on 21 August 1972. At this point in time, approximately 99,400 gallons (994,000 lbs.) of mustard agent had been destroyed during the experimental testing of the Tailor and Ton Container Systems; 79 ton containers had been incinerated.

5.2 AGENT OPERATIONS (1972)

5.2.1 AUGUST 1972 (See Figure 5–1)

Phase I Demilitarization of Bulk Agent began in the west ton container furnace on a three-shift basis at 0735 hours on Monday, 21 August 1972. The operation should have begun at 0001 hours but was delayed due to an interference with mustard monitoring when trash was being burned in the east ton container furnace. Operational problems other than the monitoring interference which occurred during this first 9 days of operation at 3 shifts were those that had surfaced during testing of the west furnace disposal system. These problems were Dustmobile electrical problems, agent spray nozzle plugging, and Moyno pump packing leaking. Some time was lost due to transferring agent from one storage tank to another by vacuum. This problem was to continue until installation of the submerged centrifugal agent pump.

There were no major system modifications during August.

Statistics for August:

T.C.'s drained: 40 H 14 HD

T.C.'s burned: 32

Average T.C.'s per day: 3.6

Downtime, total for month: 1830 min

5.2.2 SEPTEMBER 1972 (See Figure 5-2)

Demilitarization (Phase I) continued on a 3-shift basis throughout the month. Problems encountered were similar to those which occurred in August. In addition, difficulties were experienced with the scrubber pump and with failure of the high pressure relief valves in the mustard delivery piping. Agent nozzle plugging problems began to constitute a major operational problem due to agent hardening during short duration interruptions in flow associated with the ton container furnace door interlock. This interlock was supposed to add to plant safety by stopping the bulk mustard flow when the container furnace door was opened to charge or remove containers. This interruption in mustard nozzle flow allowed the mustard to harden in the nozzle.

During the period 18 through 24 September 1972, the plant was not operating due to a scheduled shutdown for installation of modifications to the east container furnace recommended by the Gross Committee (AMC Senior Advisory Panel). These modifications mainly concerned installation of additional burners in the east ton container furnace to be used in handling heavy residue weight ton containers during the latter part of Phase I and throughout Phase III (Burners 5, 5A and 6, 6A on Figure B-6). The east furnace only was to be equipped with these burners. Subsequent modification of the west furnace was later recommended and rejected. Additional work performed during this scheduled shutdown was installation of a Hastalloy B duct between the east quench and east scrubber system. The previously installed steel duct had not resisted the corrosive nature (HCl and H_2SO_4) of the quenched flue gases. A homomixer (combination homogenizer and mixer) was installed on the east mustard storage tank to aid in reducing the operationally harmful effects of the particulate matter in the storage tanks originating from the H type mustard impurities. In addition to the above work on the storage tank, the rotor and stator on the west Moyno pump were replaced, but with only limited improvement in pump pressure. Repeated pluggings of drain lines on the unload booths were experienced during September. (The pipe size was increased in the new booth to overcome this deficiency.) This may have been induced by a condition of the unload hoses discovered much later dealing with constriction of the inside diameter of the rubber hoses due to absorption of agent.

Problems with the Tailor spray dryer system began to become more apparent during September. These early problems were, specifically, the high pressure brine pump which delivers brine to the spray nozzle at the top of the dryer and the spray nozzle

itself which was deteriorating internally due to erosion from the iron oxide particles in the brine. These problems were to continue throughout the use of the Tailor dryer and the operational downtime reduced only by frequent regular repair and replacement. The nozzle was changed out every week as dictated by inspection; sooner if problem symptoms began to appear (wet or damp salt in the spray dryer bottom, wall plastering, temperature indicators, etc.)

There were no major system modifications during September other than Gross burner installation.

Statistics for September:

T.C.'s drained: 62 H 25 HD

Bulk agent burned: 132,670 lbs

T.C.'s burned: 83

Residue burned: 30,260 lbs

Downtime, total for month: 12,340 min

Average T.C.;s per day: 5.5 burned

Average residue per T.C.: 366 lbs

Overall GPM through nozzles: 0.58 (Based on total available operating minutes)

Effective GPM through nozzles: 1.25 (Based on actual operating minutes)

5.2.3 OCTOBER 1972 (See Figure 5-2)

Mustard operations (Phase I) continued on a three-shift basis. Downtime problems continued as previously observed with the exception that nozzle plugging became more frequent. A test to determine if brief and repeated opening of the mustard flow control valve (10 seconds every 5 minutes) during periods when bulk agent flow was interrupted by opening the T.C. furnace door was performed with no observable improvement. Four major downtime causes were incurred:

A. On 11 October the scrubber discharge pump motor electrical supply failed, allowing the liquid level in the scrubber bottom to rise above the opening to the quench gas outlet duct. This caused loss of negative pressure in the ton container furnaces and consequent shutdown of mustard incineration by the interlock system as designed. Emergency pumpdown was accomplished by manually holding open the pump motor relay. No log entry was made regarding corrective action taken at the time.

B. The east furnace auxiliary air fan motor failed on 12 October causing a shutdown of the east T.C. furnace. The fan was replaced.

C. During Saturday punch-list work on 21 October, the scrubber discharge fan was inspected to determine the need for rebalancing since it had been vibrating. The fan was found to be beyond repair, but would probably operate for some time. The fan impeller was to be replaced with a spare as soon as one was available.

D. The west homomixer installed in September froze and broke the motor coupling, rendering it inoperational.

The one system modification during October was replacing air-cooled agent spray nozzles in the west furnace with a new design utilizing recirculating process water for cooling. This occurred during the weekend shutdown on Saturday, 21 October. In addition to this system modification, there were two operational modifications. The first change was to increase the west furnace operating temperature from 2000°F to 2200°F in an effort to obtain more GPM from the system. There were no problems incurred at the time due to this higher temperature. The second operational change was a modification of the procedure to be used when the Tracor monitoring instruments in the monitoring station failed, as was frequently the case this early in the program. The Chief Engineer instructed the plant operating staff to continue operations during Tracor failures, providing that repairs proceeded immediately and that the scrubber effluent bubblers remained within acceptable limits. This procedure was incorporated in the Operation's Standing Operating Procedure.

Statistics for October:

T.C.'s drained: 88 H 28 HD

Agent drained: 133,551 lbs

Bulk agent burned: 145,920 lbs

T.C.'s burned: 78

Residue burned: 26,332 lbs

Downtime, total for month: 5980 min

Average T.C.'s per day: 3.9

Average residue wt. pr T.C.: 338 lbs

Overall GPM through nozzles: 0.48 (based on total available operating time)

Effective GPM through nozzles: 0.60 (based on actual operating time)

5.2.4 NOVEMBER 1972 (See Figure 5–2)

Mustard operations (Phase I) continued on a three-shift basis with bulk in the west T.C. furnace and ton containers in the east T.C. furnace. Added to the routine

downtime causes previously noted, was the unreasonably cold weather experienced during November. At 0305 hours on 2 November, a mustard unload hose ruptured spraying the interior of unload booth No. 2 with agent and contaminating two operators. This incident necessitated a change in the protective clothing requirement for use during unloading operations. Prior to this date "Congo Red" coveralls and gloves with slung mask had been deemed sufficient. The clothing required as of 2 November 1972 was changed to apron, gas mask, and congo red impregnated hood. In addition it was directed that the rotation of the ton containers with unloading hose attached was to be limited to a maximum of 45° either direction from the vertical. Change-out of unload hoses was to occur once per month with a log entry made to verify the action. Additionally, the Commander of RMA directed that every mustard demilitarization chemical plant operator be required to demonstrate to his shift engineer or foreman his job proficiency in the operations which he was performing. The Safety Office representative was to ensure that this directive was carried out. A logbook entry was made to verify that the demonstrations had taken place. An exclusion area around the front of the unload booths was marked in yellow paint on the floor with large, clearly legible notices that specified protective clothing was required within the area designated.

While attempting to start the demilitarization system on 6 November 1972, the scrubber fan impeller disintegrated due to the corrosion noted during the latter part of October. Repairs were conducted during the remainder of the week, necessitating a discontinuation of agent operations until 13 November. However, on 15 November the bearings on the replacement scrubber fan burned out and were replaced, causing 34 hours, 30 minutes downtime.

Change-out of rubber gloves in the unloading booths was directed 15 November 1972 to occur at the start of every unloading shift with a log entry made to verify the change-out. This was subsequently changed to once each shift based on engineering tests at Edgewood Arsenal.

There were two system modifications installed during November, and the inception of another:

A. The Moyno pump on the east mustard storage tank was replaced with a submerged centrifugal pump during the 6 to 13 November shutdown. Performance of this pump during November was not considered adequate due to vibration and packing leakage problems. The pump was replaced with a duplicate on 24 November. Agent pressures and startup times for this pump were superior to those obtained with the previously installed Moyno pump. The Moyno on the west tank was retained, however, due to its capability for pumping fuel oil to the bulk agent incinerator. This was considered a safety feature, since mustard could not be inadvertantly pumped to the oil tank. Centrifugal pump duration: approximately 18 calendar days.

B. The second system modification involved installation of a 22-inch sheet metal ventilation duct between the storage tank pit and the hydrazine furnace. This was to be used to ventilate agent vapors from the agent storage pit when, and if, they should occur.

C. The mustard incident on 2 November accelerated planning regarding installation of two new unload booths which would employ guillotine-type doors and place the operator and glove ports at the opposite end from the door, facing a sealed booth wall. This type of door could not be incorporated into the older unloading booths as a modification, since there was no room on the end of the booth opposite the door for glove ports, the entire unload piping setup would have to be relocated, and guillotine doors could not be fitted with glove ports.

An operational modification was made during November which limited the gross weight of ton containers placed in the east furnace to 1700 pounds or less. Using a tare of 1400 to 1500 pounds, this resulted in a maximum residue weight limit of 300 pounds. This was imposed due to the obvious difficulties which the east furnace had in coping with large residue weight ton containers.

Statistics for November:

T.C.'s drained: 49 H 18 HD

Agent drained: 99,326 lbs

Bulk agent burned: 91,530 lbs

T.C.'s burned: 112

Residue burned: 27,950 lbs

Downtime, total for month: 14,185 min

Average residue wt. pr T.C.: 250 lbs

Overall GPM through nozzles: 0.30 (based on total available operating time)

Effective GPM through nozzles: 0.70 (based on actual operating minutes)

5.2.5 DECEMBER 1972 (See Figure 5–2)

Mustard operation (Phase I) continued on a three-shift basis with bulk agent in the west ton container furnace and residue containers in the east ton container furnace. In addition to nozzle plugging, spray dryer problems, unload line plugging, and the other equipment difficulties noted during previous months, the east centrifugal pump continued to cause concern due to vibration, and consequently was run only for short periods of time. It was eventually removed on 22 December and replaced with a spare pump which operated satisfactorily for the rest of the month. It should be mentioned at this time that centrifugal pumps and homomixers removed from storage tanks were bagged and incinerated in the east ton container furnace on a specially modified section of a ton container bottom. On removal from the tank, the pumps (or homomixer) were allowed to hang from a specially installed overhead

hoist for a period of time sufficient to permit maximum drainage into the tank. The equipment was then encased in a vapor-tight, pre-prepared bag of fabric reinforced, metallized Mylar material. This entire operation was conducted in Level A clothing with the pump deck and Building 537 area declared and posted as a mask area. The area remained a mask area until bubblers registered clean. The equipment was placed in the furnace and incinerated while still in the bag. Originally, heavy plastic had been used in place of the Mylar material, but was found to be undesirable because it tore easily. The pump or mixer was incinerated until it no longer was observed to burn, removed from the furnace, allowed to cool, and sampled with a blue band tube for agent. If the results were positive, it was reburned; if negative, the pump was taken out of the plant to the maintenance shop for disassembly and rebuilt, after which it was reserved as a spare for the pump in the tank. It was only at this point that a determination could be made regarding the cause of failure.

A short test was conducted on 5 December to judge the necessity of the afterburner on the west ton container furnace. If these burners could be turned off without exceeding agent emissions, then the agent flow would be increased to make up for the temperature loss. The test was of 7-hour duration and the results were not favorable, in that stack mustard bubblers showed the necessity of the afterburner for complete destruction of the agent.

A cold weather drain-down of the brine system was implemented on the 8 December shutdown since unseasonably cold weather continued to plague startups with frozen brine and caustic lines. The problem was abated considerably by drawing all liquid from as many pipes as possible and keeping those which could not be drained (such as brine tank lines) running throughout the weekend shutdown period. Winterization housing was begun on the east scrubber system during the 16 to 17 December shutdown; however, the cold weather shutdown remained in effect even after the building annex was completed.

Bubblers throughout the entire mustard area gave high agent concentration readings from 1630 to 1848 hours on 19 December as a result of material released to the atmosphere by Shell Chemical Company. This was the first recognition by laboratory personnel that the DB 3 colorimetric analysis method for mustard was subject to interference from substances other than mustard agent. As a result, Shell was requested to supply a list of substances produced or emitted which could be screened by Quality Assurance Laboratory personnel for interference with the DB 3 method. The list was supplied, screened, tested by Quality Assurance and, resulted in a list of 10 interference producing compounds for future reference. This interference also occurred with the Timalog rapid response monitors.

Modifications during December consisted of the initial work required to bring the hydrazine furnace into the desired configuration to burn bulk agent. The furnace was fired on natural gas to 2050°F on 18 December as part of the checkout of its systems.

Statistics for December:

T.C.'s drained: 97 H 35 HD

Agent drained: 178,903 lbs

Bulk agent burned: 171,870 lbs

T.C.'s burned: 105

Residue burned: 39,864 lbs

Downtime, total for month: 4560 min

Average T.C.'s burned per day: 5.5

Average residue wt. pr T.C.: 380 lbs

Overall GPM through nozzles: 0.63 (based on total available operating time)

Effective GPM through nozzles: 0.75 (based on actual operating minutes)

5.3 AGENT OPERATIONS (1973)

5.3.1 JANUARY 1973 (See Figure 5–3)

Mustard demilitarization operations (Phase I) continued on a three-shift basis with bulk agent in the west ton container furnace and residue ton containers in the east container furnace. Equipment difficulties previously noted continued to interrupt operations.

A mustard accident occurred at approximately 1800 hours, 3 January when agent leaked from the flange on the east mustard pump and dripped onto the storage tank top in the tank pit. Two operators were exposed and treated for mustard agent burns. Incorrect procedure used in emptying the vacuum dropout pot with compressed air resulted in pressurization of the east mustard storage tank and subsequent pump flange leakage. The leakage was turned into a spray by the spinning pump shaft, and carried onto the operators by a hot air stream from the tank pit space heater. Equipment modifications resulting from this incident were removal of the compressed air line from the dropout pot and installation of a deflector in front of the space heater. Operational changes were that operating personnel were to have alarm lights checked by an instrument man prior to carrying out agent operations indicated by the alarm light, and that SOP's be revised to cover in detail transfer of agent from the dropout pot to the agent storage tanks by vacuum.

The centrifugal pump which had been installed on 22 December had to be changed out again on 6 January 1973 since it had developed a sudden loss in outlet pressure despite indications of normal functioning. Upon decontamination, it was found that a hole had been worn through the right-angle elbow where the pump outlet makes a directional change from the horizontal volute to the vertical outlet line. It was thought that continuous erosion caused by the abrasive nature of the mustard agent impurities had caused the hole to develop. The pump had continued to operate as designed, but the liquid (rather than being forced to the pump deck) was being pumped back into the tank.

The scrubber exhaust fan, which had been replaced during the 6 to 13 November 1973 period, started to exhibit signs of deterioration during the early part of January. Consequently, the impeller was rebalanced on 13 January during the weekend maintenance period. However, on 19 January at 1100 hours, the impeller disintegrated, resulting in major damage to the fan housing, mounting base, and motor mounts. This disintegration was the result of a condition which had not appeared during the early months of the pilot work on the system. The fan impeller, which was constructed of 3/8-inch steel and coated with an epoxy material, was observed to have become eroded and corroded over a short period of time. The corrosion was indicated by the pitting of the metal after the epoxy coating had been worn away. The erosion was probably the result of the continuous abrasion to which the metal was subjected by the presence of brine carryover from the scrubber, containing a high percentage of iron oxide particles. The fan housing was also exhibiting signs of deterioration due to corrosion and erosion. This housing was damaged in the impeller disintegration by pieces of the impeller piercing its plate, and by the severe vibration experienced when the impeller became greatly imbalanced. The fan impeller was replaced with a spare, as was the housing and motor mounting. The housing was eventually rubber-coated to prevent erosion of the housing. The rotor remained low carbon steel, since improved materials could not be obtained on a timely basis.

As a result of the failure of the homomixer on both storage tanks, and in an attempt to reduce the downtime associated with agent nozzle plugging, the Mustard Demil Office instructed the operating staff to change the mixture of H and HD being incinerated (currently at 2.5 parts H to 1.0 part HD by weight) to HD entirely. This burning mixture was regulated by the number of containers of each type of agent dumped in a given operating day. Since the H mustard left a considerable residue in the ton container, this approach did not always yield the desired 2.5 to 1.0 ratio, but it was a simple and effective way of regulating the mixture. The switch to HD was made due to the recognized low residue content of the agent and it was felt that this would decrease the nozzle plugging problem. It was in a large measure successful, though the problem persisted until the introduction of the hydrazine furnace in March 1973. It should be added at this point that the initial 2.5 to 1.0 mixture of agents fed to the burn nozzles was essentially the same as the ratio of H to HD contained in the starting inventory of agent. The changeover to only HD was made reluctantly and anticipated a successful introduction of the hydrazine furnace with its larger agent nozzle which possessed less potential for plugging. The all-HD burning also eased the scrubber fan problem by decreasing the amount of iron oxide put through the system. This change did prove to be beneficial.

On a routine weekend inspection and cleanout of the scrubber, it was observed that the residue on the bottom of the vessel contained approximately 5 each of 30-gallon drums of glass Raschig rings. These rings had fallen through the holes eroded in the top of each of the weirs of the stainless steel packing support plate. These holes were patched from underneath and a steel I-beam support (which was judged to be unstable) was removed. Additional supports were placed in the scrubber bottom and a weekly visual inspection of this support plate instituted. Plans were immediately made for fabrication of a replacement plate constructed of Hastalloy B to be installed, when required.

System modifications during January were: (1) the completion of east furnace scrubber nozzle setup preparatory to start of Phase II burn in both T.C. furnaces, and (2) continuation of preparation of the hydrazine furnace for bulk agent use. This took the form of rebricking the furnace barrel and installation of a wall in the furnace breeching separating the hydrazine furnace from the west ton container furnace to ensure that men could work safety in the hydrazine furnace.

Statistics for January:

T.C.'s drained: 53 H 81 HD

Agent drained: 201,345 lbs

Bulk agent burned: 195,220 lbs

T.C.'s burned: 94

Residue burned: 19,997 lbs

Downtime, total for month: 8200 min

Average T.C.'s burned per day: 4.3

Average residue wt. pr T.C.: 212 lbs

Overall GPM through nozzles: 0.62 (based on total available operating time)

Effective GPM through nozzles: 0.83 (based on actual operating minutes)

5.3.2 FEBRUARY 1973 (See Figure 5–3)

Mustard demilitarization operations (Phase I) continued on a three-shift basis with bulk agent in the west ton container furnace and residue ton containers in the east container furnace. Operations during February proceeded at an almost uninterrupted pace, due primarily to the lack of nozzle plugging problems associated with all HD incineration.

February was the beginning of intensive effort of system testing which was to continue for some nine months, with only brief interruptions. To present the chronology of operations, a brief summary of each test plan will be contained in this section, where applicable. During October 1972, some work had been performed on a test plan for evaluation of the burner modification to the east furnace recommended by the Gross Committee. Five containers were incinerated according to test plan without satisfactory results other than the conclusion that the Dynasciences SO_2 monitor sampling from the east furnace flue could possibly be used in an attempt to shorten the burning time of lighter weight (less than 300 pounds residue) ton containers. The test plan for this "Dynasciences Test" was prepared by the Mustard Demil Process Engineering section on 7 February, and after approval by the Program Manager, the test was performed during the period 13 to 26 February utilizing 59 residue ton containers.

The scrubber exhaust fan continued to be inspected each weekend and appeared to continue in generally good condition. A rebalance was required on 19 February, however. The quench tank was becoming more of a problem in that there was a continual buildup of salt on the walls of the vessel, particularly around the brine spray nozzles. This salting up problem on the east quench was never satisfactorily solved. A weekly washdown of the vessel was required as well as removal and cleanout of the nozzle wells during operations.

During February, the system modifications consisted of the completion of the east scrubber winterization building annex and the final shakedown of the hydrazine furnace controls prior to its scheduled run-in during March 1973. A test plan for this run-in was prepared on 12 February 1973 and forwarded to the Program Manager for approval. When it was received, this approval was qualified in that the Operations Management Division of the Program Manager's Office intended to give approval of each phase of the test as the preceeding phase was completed. The initial "go-ahead" was received on Test H-1 by message on 22 February 1973.

Statistics for February:

T.C.'s drained: 0 H 159 HD

Agent drained: 264,356 lbs

Bulk agent burned: 248,710 lbs

T.C.'s burned: 164

Residue burned: 22,180 lbs

Downtime, total for month: 2250 min

Average T.C.'s burned per day: 8.6

Average residue wt. pr T.C.: 135 lbs

Overall GPM through nozzles: 0.91 (based on total available operating time)

Effective GPM through nozzles: 0.99 (based on actual operating minutes)

5.3.3 MARCH 1973 (See Figure 5–3)

Mustard Demilitarization Operations (Phase I) continued on a three-shift basis with bulk agent in the west T.C. furnace from 1 to 19 March and in the hydrazine furnace from 19 to 31 March. Residue containers continued to be burned in the east container furnace as normal. Downtime problems occurring in March were similar to problems already experienced. Nozzle plugging in the west furnace continued to occur but at a much reduced frequency due to the high HD content of the mustard feed. One problem which was not seen since November was the plugging of the unload hoses.

It appeared the monthly change-out also helped solve the line plugging. This is reasonable, since one of the results of an Edgewood Arsenal test on mustard absorption by the hoses was that the hose inside the diameter became more constricted with longer use of the hose.

The condition of the scrubber exhaust fan continued to be monitored on a weekly basis. On 3 March, it was observed that the blades were beginning to erode. The condition continued to deteriorate to the extent that the impeller was changed out on 17 March before it would disintegrate. Spare impellers had been ordered on a "rush basis". This last change-out left no spare impeller in the warehouse for future use. The next impeller was not due until mid-April. The installation of the new electrostatic precipitator (ESP) projected for on or about 1 May would solve the scrubber fan impeller problem since the new driving fan would be in a hot, dry, clean gas stream rather than the cool, wet, dirty stream which was the environment of the present fan. Observations of the impeller on the Dustmobile outlet fan over the past four months had indicated that this would be the case since this impeller showed little or no erosion damage.

The hydrazine furnace test plan developed during February was carried out during March. Test H-1 was performed on 7, 8 and 12 March with the stated objective of learning the furnace characteristics and discovering problem areas before the introduction of live agent. This test was accomplished after the breeching wall was removed that separated the hydrazine furnace from the east scrubber system. Second, initial problems which occurred were solved by modifications of the furnace. Results of this test led to the conclusion that the next steps in the test, H-2 through H-5, involving live agent, could be carried out safely. The agent burning tests were conducted on 12 and 19 through 23 March and resulted in certification of agent burning of as much as 1.9 GPM of agent mixtures from zero H to all-HD with no nozzle plugging. The normal operating temperature of the furnace breeching was 1800°F and was used as the controlling temperature. The use of the east ton container furnace during hydrazine furnace bulk burning was feasible; however, the high fire/low fire adjustments of the burners needed adjustment inasmuch as there was considerable trouble maintaining the nominal 1000°F baseline temperature; actual temperatures were observed to run considerably higher and erratically. On 26 March, the controlling temperature of the hydrazine furnace was changed to 1900°F where it would stay until September 1973.

A new homomixer was installed in the west storage tank on 14 March; however, its use was discontinued on 23 March when it went out of order. It was fairly well determined that operation could be accomplished without the homogenizer. Considerable trouble was experienced with the centrifuge mustard pump packing. Continuous adjustments of the packing tightness had to be made to stop agent leakage. The packing was eventually tightened to the point that the leakage was stopped; no pump changeout was required.

The Bowen spray dryer was completed during March and received its first operational checkout. Crew training began on day shift, 21 March and continued during day shift until each of the three crews had been trained in the unit's

operation. The Contractor who had considerable testing and changing to do before all system requirements were met, maintained a full-time engineer on site for the first year of operation.

System modifications during the month, in addition to the introduction of the hydrazine furnace, consisted of repairs to the recently installed guillotine door which led from the central furnace breeching to the 200-foot brick stack. This chain-operated door was originally installed to assist in startup and cooldown of the furnaces and as an emergency draft source in event of a power or furnace failure while a ton container was burning. The hydrazine furnace testing showed that considerable leakage of the flue gas was incurred around this door either with or without the 200-foot stack fan operating. Some steps were taken to seat the door better, but these were not entirely successful.

A test program for Phase II of the "Dynascience" ton container test was submitted on 26 March 1973 with testing to begin during April 1973.

Statistics for March:

T.C.'s drained: 95 H 127 HD

Agent drained: 335,127 lbs

Bulk agent burned: 317,210 lbs

T.C.'s burned: 244

Residue burned: 26,899 lbs

Average T.C.'s per day: 11.1

Average wt. per T.C.: 110 lbs

Downtime, total for month: 3469 min

Overall GPM through nozzles: 1.00 (based on total available operating minutes)

Effective GPM through nozzles: 1.12 (based on actual operating minutes)

5.3.4 APRIL 1973 (See Figure 5–3)

Mustard demilitarization operations (Phase I) continued on a three-shift basis with bulk agent in the hydrazine furnace and residue ton containers in the east container furnace. Downtime and equipment problems previously experienced continued, with the exception of the nozzle plugging. The Tailor spray dryer continued to operate at least two shifts per day with the same pump, nozzle, and plastering problems experienced. The dryer had to be shut down for cleanout at an interval of two to three days.

The scrubber exhaust fan problem continued throughout April. Agent burning was discontinued on 2 April (2320 hours) due to the bad condition of the fan. The fan was removed on 3 April and taken to the maintenance shop to be rebuilt, in that no spare impeller was available. This rebuild and reinstallation time took until 5 April, at which time the agent burn was restarted. A total of 67 hours and 15 minutes of agent burning time was lost during this downtime period. A further shutdown of approximately 4 hours was incurred on 11 April to check and rebalance the fan impeller. A spare impeller was received during the week of 10 April and was used to replace the rebuilt impeller on 14 April during a weekend shutdown. Again, there was no spare impeller on the Arsenal but fortunately, the new ESP was on schedule with installation set for the first week in May. Examination of the new fan impeller on 21 April indicated that the blades were beginning to pit and erode. These impeller problems occurred despite a cutback on the hydrazine furnace burn rate on 5 April to conserve the fan blades. However, it was not realized that the majority of the abrasive material came from scrubber brine carryover which contained a great deal of iron oxide despite the decrease in this material's production.

The east centrifugal pump continued to give problems with packing leakage. This problem was a carryover from March. The pump was eventually changed on 14 April with a rebuilt unit. However, this replacement broke a motor coupling on 16 April after 10 minutes' operation. Repairs were quickly made, and the pump was placed in operation until 18 April, when a pinhole leak developed in the discharge line. Attempts to weld this leak failed, and agent pumping operations were switched to the west tank's Moyno pump. The centrifugal pump was replaced on Saturday, 21 April and continued to operate satisfactorily throughout the remainder of the month.

During April, the first signs of another problem began to appear. Small leaks were beginning to develop in the flanges of the Hastalloy B quench/scrubber duct. These leaks were to continue to increase in size and number until the duct could be replaced in November 1973. For the moment, patches were welded to the flange leaks. This problem was accentuated by the use of stainless steel welding rod, rather than using Hastelloy B rod with heliarc welding.

Weekly checks of the east scrubber bottom continued to be made. During the inspection on 14 April, an I-beam support was observed to have eroded to the point where it was no longer sound, and was replaced.

On 3 April, the Director of Mustard Demilitarization requested that the RMA Safety Office seek approval to increase the minimum storage limit of the Building 537 thaw room from 72 containers to 90 containers.[2] This request was based on the need for additional storage capability commensurate with the increased capability of the hydrazine furnace and the anticipated beginning of Phase II with its 2 GPM bulk agent rate. This recommendation was acted upon by RMA Safety during May 1973.

The ton container furnace tests, which were to have been carried out in April, were postponed until after ESP installation due to the inability of the ton container furnace system to regulate its temperature satisfactorily. Data from this section of the test was discarded as being of little comparative value to the later data collected.

On 24 April, RMA received approval to proceed with acquisition of the west scrubber system. This system was needed for the 2 GPM burn rate of mustard during Phase II, and the heavy residue weight ton container burn during Phase III.

As a result of a directed action at the Program Review and Analysis meeting conducted on 1 to 2 March 1973, RMA studied the feasibility of utilizing the hydrazine furnace nozzle system in the west ton container furnace in an attempt to increase the rate of mustard disposal.[3] Cost and time considerations, however, dictated that the idea should be dropped. The Program Manager concurred in this recommendation on 10 June 1973.[4]

There were no significant changes in the Mustard Disposal System configuration during April. The Bowen spray dryer status is covered later in this section.

Statistics for April:

T.C.'s drained: 236 H 18 HD

Agent drained: 357,412 lbs

Bulk agent burned: 311,750 lbs

T.C.'s burned: 157

Residue burned: 235,573 lbs

Average T.C.'s per day: 7.5

Average wt. per T.C.: 150 lbs

Downtime, total for month: 6318 min

Overall GPM through nozzles: 1.03 (based on total available operating minutes)

Effective GPM through nozzles: 1.30 (based on actual operating minutes)

5.3.5 MAY 1973 (See Figure 5–4)

Mustard demilitarization operations (Phase I) continued during May with bulk agent in the hydrazine furnace and residue containers in the east container furnace.

The plant was shut down at 1130 hours, 3 May to tie in the new electrostatic precipitator (ESP). Construction of the unit had been completed with the exception of the duct between the scrubber outlet and the ESP inlet. During installation of this duct, it was discovered that the wire mesh mist eliminator in the scrubber tower which had previously been present above the packing had collapsed, due to corrosion/erosion and was lying on the scrubber brine distribution plate below the brine feed header, and was effectively channelling the flow of brine down through

the pack. The remainder of the mist eliminator were removed during this time period. The shutdown for ESP tie-in lasted a total of 75 operating hours with the plant being restarted on 8 May. Approximately 7 operating hours were consumed with checkout of the new system. An evaluation of the dust collection properties of the precipitator was to be performed by USAEHA during July 1973. The responsibility for operations and normal maintenance of the ESP was formally accepted on 9 May 1973.[5] The ESP proved to be essentially a turnkey operation.

Due to poor scrubber performance during the initial running period with the ESP, it was decided to acid-wash the east scrubber system on 23 May. On inspection of the scrubber bottom, maintenance personnel observed that the packing support plate and its supports had deteriorated to the extent that it could not be relied upon to continue to support the packing. This condition was probably a combination of corrosion of the original stainless steel support plate and accelerated erosion due to the larger volumes of air being moved through the system by the new ESP configuration. A decision was made to shut down the plant, and make use of the long Memorial Day weekend to complete the installation of a new support plate with as little loss of operating time as possible. This new support plate had beed fabricated of Hastalloy B plate after the repairs were made to the stainless steel support plate in January. The operation was carried out efficiently with a loss of only 63 operating hours. The packing was removed via a manhole in the side of the scrubber vessel. The packing rings were placed in 55-gallon drums and carried outside of the winterization annex where the rings were spread on some scrap steel mesh and washed with water. The cleansed rings were then replaced in the drums for repacking the tower. Maintenance personnel removed the stainless steel packing support and welded the Hastalloy plate in place, replacing all of the plate support I-beams in the process. The packing was replaced by flooding the scrubber tower and floating the packing into place through a manhole near the top of the scrubber vessel. After all ducting and piping was reconnected, the system was started up and worked perfectly. The plant was back in operation on 29 May.

There was no downtime experienced during May which was attributable to the bulk mustard feed system.

Immediately prior to the installation of the precipitator, the hydrazine furnace incurred considerable damage due to the collapse of the upper portion of the firebrick insulating wall which had been installed in the north end of the furnace around the combustion chamber (see Figure 5–3). This firebrick apparently collapsed because part of the supporting structure was the old steep supporting structure which formerly had been sufficiently cooled to prevent deterioration; but with the modifications earlier, the steel was overheated and eroded, and finally collapsed. There did not appear to be any other form of thermal damage. A portion of the brick lining from the top of the combustion chamber also collapsed due to deterioration of the mortar binding. From observation of this damage, it was decided to rebuild the north wall and the combustion chamber using a rammable refractory material rather than firebrick. This material, forced into position and molded with air hammers, was installed during the ESP tie-in shutdown. Subsequent performance of this rebuilding, after a careful heat treatment process, was excellent

with little deterioration being observed throughout the remainder of the program. This revised structure sufficiently insulated the remaining structural steel to preclude further damage.

Installation of the new unload booth foundations began during May with completion of the new booth scheduled for June 1973. Work was begun on the fabrication in the maintenance shop of the quench tank and scrubber vessel for the west scrubber system.

Ton container testing which was to have been resumed during May. was postponed until the beginning of June due to the ESP checkout and the scrubber repairs.

The Bowen spray dryer was run on a 3-shift basis during May. Several serious discrepancies still existed during the month. Installation of the thirteen-inch spray disc had almost eliminated the problem associated with the plastering of the chamber wall: however, the smaller size of the particles achieved was creating problems with the compactor. Some drying interruption was experienced due to the fact that the compactor feed screw and the compactor hopper feed conveyor belt were not handling the salt as fast as it was being generated. The Bowen representatives were requested to present, in writing, through the Corps of Engineers, their plans for resolving these discrepancies. Additionally, a scheduled stack particulate survey (set for July 1973) was to determine whether discrepancies relating to particulate emissions were to be resolved as well.

A letter went forward on 14 May 1973 to Commander, USAMC, through Commander, USAMUCOM, referencing the request for additional ton containers required in the thaw room to support increased agent operations to begin in June 1973.[6] This letter outlined the reasons behind the need for additional storage authorization. This request was approved by the Chief of the AMC Safety Office on 29 May 1973 and forwarded to the Chairman of the Department of Defense Explosives Safety Board for revision.[7]

Statistics for May:

T.C.'s drained: 252 H 29 HD

Agent drained: 394,133 lbs

Bulk agent burned: 338,810 lbs

T.C.'s burned: 122

Residue burned: 17,621 lbs

Average T.C.'s per day: 6.1

Average wt. per T.C.: 144 lbs

Downtime, total for month: 7870 min

Overall GPM through nozzles: 1.07 (based on total available operating minutes)

Effective GPM through nozzles: 1.42 (based on actual operating minutes)

5.3.6 JUNE 1973 (See Figure 5–4)

Mustard operations during June 1973 proceeded into the revised Phase II schedule which called for bulk agent incineration at 2 GPM in the hydrazine furnace and residue containers in the east ton container furnace. Downtime problems experienced during June were minimal with the plant (bulk burning operation) operating 90.2 percent of the total available time. The only major problem encountered was a failure of the scrubber discharge pump which allowed the scrubber system to flood the quench/scrubber duct and rob the furnaces of draft. During this draft loss, the lack of system airflow caused the preheater to overheat the first bay of the ESP, resulting in some heat damage to low melting point components of the electrical grid. The preheater was manually controlled and was never judged to be a satisfactory piece of equipment either from dependability or from a controllability standpoint. Due to the requirements of other portions of the program, a redesign of the preheater configuration was not effected other than a relocation which occurred in July 1973.

The ESP continued to operate in a most satisfactory manner with only minor problems associated with insulator breakage and discharge control circuits. More frequent cleaning (weekly) was placed in effect and helped to solve the insulator breakage problem. Arcing on the surface of the insulators were causing breakage; the air wash on the insulators did not prevent breakage. Control circuit modifications to the control panel were made under warranty by General Electric Corp. A test of the ESP stack by Lear-Siegler Incorporated, utilizing a stack-mounted optical transmissometer indicated that at approximately 2 GPM of bulk agent burn, and during a peak ton container burn, the stack was showing 5 percent opacity with only two of the five bays of the precipitator functioning electrically. While this did not constitute an acceptance test of the precipitator, it did indicate that the unit would have no trouble in passing the AEHA evaluation which had been slipped to August 1973. Formal acceptance depended on a visual test by Colorado State Inspectors. A problem which was not related to the operation of the ESP itself, surfaced during June. This problem was associated with the condensation in the ESP stack of a strongly acidic material which was periodically blown from the top of the stack. It was not possible to arrive at a chemical composition of the material due to the salt carryover from the scrubber. It was, however, decided that the material was probably sulfuric acid which was condensing in the laminar flow (or plug flow) vertical section of the stack where the gas stream impinged on the relatively cool stack wall. The gas stream temperature was in excess of 350°F normally; however, the wall temperature was approximately 250°F under normal ambient temperature conditions. A work order was generated to insulate the stack to prevent this condensation. Since the insulation would cover up the wind loading relief vanes, which were installed as part of the original ESP equipment, the stack was guyed with wire cable. When these modifications were subsequently performed, the condensate problem was satisfactorily remedied.

Approval of the 100-ton container thaw room storage capacity limit was received from MUCOM during the month with approval by AMC having been received at MUCOM on 20 June 1973 and from DDESB on 11 June 1973.[8] A source sampling survey of the Bowen spray dryer was conducted during June. The new precompaction screw (third modification) provided by Bowen for the compactor appeared to have resolved the compactor feed rate problem. A decrease in atomizing disc speed proposed by Bowen, designed to increase the particle size of the salt and thus increase the effectiveness of the precompaction screw, was deemed not necessary in light of the adequate performance of the new precompaction screw.

The guillotine door to the 200-foot stack was bricked shut on 17 June. Repeated efforts to correct the leakage past this door had not resulted in elimination of the 200-foot stack plume resulting from the particulate matter being pulled straight from the furnace breeching flue gases. The basic problem related to the fact that both a thermal barrier and a gas seal were tried to be incorporated in one door. It appeared that a secondary door to act as a gas seal after the thermal barrier would have worked.

Tests associated with the optimization of ton container furnace residence times were completed during June. The implementation of reduced residence time burning procedures resulting from these tests had no initial impact on the burn rate of containers since the implementation occurred on 28 June. An increase in burning rate during the latter part of the month (see Table 6–5) can be attributed to the latter stages of the testing program.

Construction work on the west quench/scrubber system was proceeding during June. Installation of the shell of the new unload booth was completed during June. Completion of required equipment and controls was proceeding. Approval of the revised SOP for the new unload booth was received from HQ, USAMUCOM, on 12 June[9] in response to a letter from RMA Safety Office providing the design and SOP changes for review. This request for approval went through HQ, USAMC and DDESB, as was normal.

Statistics for June:

T.C.'s drained: 385 H 41 HD

Agent drained: 576,260 lbs

Bulk agent burned: 514,451 lbs

T.C.'s burned: 195

Residue burned: 34,081 lbs

Average T.C.'s per day: 9.3

Average residue wt per T.C.: 175 lbs

Downtime, total for month: 2960 min

Overall GPM through nozzles: 1.70 (based on total available operating minutes)

Effective GPM through nozzles: 1.89 (based on actual operating minutes)

5.3.7 JULY 1973 (See Figure 5–4)

The mustard disposal operation (Phase II) continued on a three-shift basis with bulk agent in the hydrazine furnace and ton containers in the east container furnace. Operations downtime problems continued at a minimum. The centrifugal agent pump required replacement due to impeller wear. This long run proved the increased effectiveness of the centrifugal pump over the Moyno pumps for bulk mustard pumping. The mustard flow control valve at the hydrazine furnace was exhibiting signs of plugging; consequently it was changed out at the same time.

The major downtime problem occurring during July was the plant shutdown on 24 July to decontaminate a major mustard spill in the thaw room. The spill had occurred during the weekend shutdown period just prior to startup on Sunday night. Approximately 1100 pounds of agent was spilled from a ton container when a deteriorated plug on the end of the container opposite the valve leaked. Decontamination required a total of 16 hours. There were no emissions to the atmosphere and no personnel casualties were caused.

The ESP continued to operate satisfactorily throughout the month.

Preparations were made during July to start the ton container test plan for heavy residue containers during August.

The new unload booth was completed and tested with a fuel oil-filled container by 31 July. Actual draining operations with this booth were to begin on 1 August.

The ton container cut and scrape operation apparatus was completed and tested during July. Startup of this operation was to be postponed until a redesign of the cut container handling equipment could be effected during August.

Work on the west quench/scrubber system continued on schedule.

The Bowen spray dryer was operated on a three-shift basis throughout the month of July. Salt conveyor belt problems continued to occur. Additionally, the stack opacity continued to run above 20 percent. Bowen Engineering was in the process of designing a high-energy venturi scrubber to aid in removal of the micro-sized particles which were causing the problem.

Statistics for July:

T.C.'s drained: 355 H 40 HD

Agent drained: 572,400 lbs

Bulk agent burned: 464,139 lbs

T.C.'s burned: 238

Residue burned: 45,522 lbs

Average T.C.'s per day: 11.3

Average residue wt. per T.C.: 191 lbs

Downtime, total for month: 2890 min

Overall GPM through nozzles: 1.53 (based on total available operating minutes)

Effective GPM through nozzles: 1.70 (based on actual operating minutes)

5.3.8 AUGUST 1973 (See Figure 5-5)

The mustard disposal operation (Phase II) continued on a three-shift basis in a highly satisfactory manner. Bulk agent was incinerated in the hydrazine furnace and ton containers in the east ton container furnace. Downtime problems for the month included a reappearance of mustard flow control valve plugging. There were some indications as well that the pipe leading to the mustard nozzle was plugging periodically; repeated attempts to flush the lines with oil were unsuccessful. One hypothesis of the reason for the plugging was that the increased effectiveness of the new unloading booth was drawing more particulate into the storage tanks which contributed to a buildup of solids in the tanks to the point where the agent pumps were picking up more of this abrasive material than previously. The accuracy of this hypothesis is borne out by the fact that the centrifugal agent pump which had been replaced in July had to be replaced again on 29 August. The agent nozzle and feed system were replaced to remedy the plugging problem. Additionally, the amount of HD dumped into the agent tanks was increased. These measures were successful to some extent. It was necessary to raise the hydrazine furnace operating temperature (from 1800°F to 1900°F) to increase agent gallonage from the furance to offset the mustard feed difficulties. Homomixers were not in operation due to previous failures, but it is doubtful whether they would have had any effect other than stirring up more solids from the bottom of the tanks.

Considerable difficulty was experienced, not only in August, but in previous months, with the deteriorating conditions of the quench/scrubber duct. Holes continued to appear in welds and at the flanged points at the quench and scrubber. The duct eventually became structurally weaker and required support by cables from the roof of the winterization structure; this final condition did not occur, however, until October. In addition to this deterioration, the quench duct continued to salt up and plug. Two additional nozzles were installed at the point the duct exited the quench in order to attempt alleviation of the salting-up by keeping the area wet with brine. This measure was, to a large extent, successful. The salt plugging problem was not satisfactorily resolved on the east scrubber; however, the west scrubber with its improved design did not experience this problem. Replacement of the Hastelloy nozzles in the east quench tank continued to be required on a very frequent basis.

The electrostatic precipitator continued to function satisfactorily throughout August. AEHA performed its evaluation of the particulate emissions during the latter part of the month. Initial unofficial results presented at the time indicated that the unit had no trouble meeting the State of Colorado's emission limitations on only two stages operating out of the five. This evaluation took place at 2 GPM and during the peak burns of successive heavy residue weight ton containers. A configuration change which took place just before the evaluation was that the ESP preheater was moved from the lower 90° duct elbow to the upper 90° duct elbow located at the base of the Y-shaped duct section, which had been installed when the ESP was tied into the system. This preheater move was made on 18 August on the recommendation of a technical representative from Precipitair Pollution Control. The thinking behind the move was that the new position afforded a much larger run of duct in which more intimate mixing of the air stream and the hot air could occur. This would result in a much drier airstream entering the first bay of the precipitator, eliminating the collection of scrubber brine carryover in the dust bin at the bottom of the first bay. The preheater in its new location worked as expected, with collection of liquid in the first bay of the precipitator ceasing to be a problem. Normal weekend cleanout of the precipitator continued, however, and was expanded to include cleaning of the insulators and washdown of the dust collection hoppers. An additional weekly cleanout step was to wash down the inlet duct and inlet diffuser plate with a water hose used through a working access plate installed on the ESP exhaust fan inlet through which a weekly check of the fan damper and the fan impeller could be made. Initial inspection results indicated that no observable deterioration of the fan had occurred during the period of its operation.

Heavy ton container tests were conducted during August. The evaluation consisted of an attempt to devise the most effective burner configuration for incinerating large residue weight containers. Concurrent with this was the objective of developing the criteria necessary for minimizing heavy container residence time in the furnace. Posting of revised burning procedures during August resulted in a large increase in the average weight of residue per container during that month and in subsequent months. An effort was made starting 23 August to conserve light weight (1850 pounds or less gross weight before burning) containers for use in the west furnace when it was expected to be operational at the completion of the bulk agent burn on, or about, 1 October.

The new unload booth was in full operation by 14 August. Its superior draining capabilities were almost immediately apparent; consequently, use of booth number 3 was discontinued. There were no significant difficulties with this new unload booth configuration. Based on the success of the new unload booth (designated 1A) RMA suggested at the program review of 15 August 1973 that the construction of the second new unload booth which had been planned to be cancelled. No work other than parts and shell procurement had been done. The Program Manager concurred in this recommendation by letter on 24 August 1973.[10]

An additional subject which was examined during August[11] was the approach to handling ton containers which for one reason or another could not be emptied during the first drain attempt. The problem was to be remedied by a two-part operation involving changeout of the normal container valves initially and

subsequent installation (in the toxic yard) of a plug adapter containing a standard T.C. valve in a plug hole only if the initial valve changeout did not allow the containers to be drained. Handling of containers with plug adapters was to be done under increased safety criteria concurred in by the RMA Safety Office.[12] This was necessary since the adapter extended beyond the end of the container.

The test plan for shakedown of the west quench/scrubber system was submitted for approval on 15 August.

The Quality Assurance monitoring station located at the base of the ESP stack was completed and operational as of 13 August. Prior to this date, the effluent gas stream monitoring had been performed with samples drawn from the scrubber outlet duct. This particulate-laden, saturated gas stream had provided samples of a less than ideal nature. Despite initial problems with sampling probes corrosion (due in part to the acid condensation in the stack previously mentioned) the new location provided a much cleaner sample which was essentially free from particulate and condensate interference. The Dynasciences stack SO_2 monitor in particular responded very well to the upgraded sample quality.

The Bowen spray dryer continued to be operated throughout August and did not cause any downtime to the incineration operation. Some difficulty continued to be experienced with the salt conveyor belt and compactor. Stack emissions were still in excess of the State of Colorado limits; however, installation of the venturi scrubber was to occur after the completion of bulk agent incineration when the reduced brine generation rate would allow use of the Tailor spray dryer to meet all requirements.

Operation of the ton container cut and scrape apparatus was not begun due to modifications being made to the system.

The installation of the west quench/scrubber continued during August despite the fact that the ultimate completion date would have to be slipped until early October.

Statistics for August:

T.C.'s drained: 293 H 104 HD

Agent drained: 574,230 lbs

Bulk agent burned: 545,840 lbs

T.C.'s burned: 155 lbs

Residue burned: 47,994 lbs

Average T.C.'s per day: 6.7

Average residue wt. per T.C.: 310 lbs

Downtime, total for month: 2955 min

Overall GPM through nozzles: 1.65 (based on total available operating minutes)

Effective GPM through nozzles: 1.81 (based on actual operating minutes)

5.3.9 SEPTEMBER 1973 (See Figure 5–5)

Mustard disposal operations continued in a satisfactory manner throughout September. Phase II was completed at 2155 hours on 25 September with the completion of the disposal of all bulk agent except for 23 ton containers reserved for west quench/scrubber testing and 11 ton containers reserved for CAMDS testing in December 1973 and March 1974. Phase III, the incineration of the remaining residue ton containers, was begun immediately, utilizing both the east and west ton container furnaces. Residue weight limits initially set for the east furnaces were that burning should be confined to containers of greater than 1901 pounds gross weight before burning. This equates to a minimum residue limit of approximately 300 to 400 pounds. There was no upper residue weight limit since large residue weight containers could be safely handled utilizing the burning procedures developed during the heavy ton container test program and posted in the plant during August. A maximum residue weight limit of 300 to 400 pounds was established on the west furnace since this furnace's capabilities were still not completely known.

Downtime for September was minimal with a total of only 22 hours being recorded. The hydrazine furnace alone operated 94 percent of the available time. Some difficulty was experienced with the continuing mustard feed problems observed during August. The hydrazine furnace stack temperature set point was increased from 1900°F to 1950°F on 12 September to increase agent GPM. It was necessary to replace the centrifugal agent pump again on 10 September.

During September, the west ton container furnace was rebricked preparatory to its startup at the completion of bulk burn. This rebricking was completed by contractor personnel as was all of the previous furnace bricking work. A barrier was placed in the west furnace flue opening effectively isolating the furnace from the rest of the furnace system. Contractor personnel worked in this sealed furnace with the door open while the east furnace operation continued. All contractor personnel wore "congo red" clothing while working inside the furnace. Bubbler readings taken prior to the start of rebricking had indicated that the furnace was free of contamination. Installation of a sprinkler system in Building 538 was also accomplished by contractor personnel during this period.

As a result of the thaw room spill of 23 July, a directed action was made during the 15 August program review to install a remote alarm system for monitoring the thaw room during weekend shutdown periods. The original approach suggested was a type of wire communication from the thaw room Titralog directly to the RMA fire station. This approach was examined by RMA[13] and found to be undesirable due to lack of existing equipment and the cost of installing the required hardware between the plant and the fire station. RMA recommended an alternate plan which involved the use of a flashing light located outside Building 537 in a readily observable location. This light was to be monitored by regular Security patrols passing the plant. A flashing light indication of a Titralog alarm was to trigger a notification by

radio or telephone to the Fire Department who would enter the plant and visually inspect the thaw room for a spill. If a spill was observed, the Fire Department was to initiate the Arsenal Chemical Accident/Incident Control Plan (CAICP) which would function normally for decontamination. In event that no spill could be located visually, either a Quality Assurance or an Operations representative (or both) were to be called to investigate. Since the Titralog was subject to interference from Shell Company emissions, an investigation of the instrument by a QA man was desirable. This alarm system was approved in concept by the Program Manager, and implemented on 28 September 1973.[14] Although no further leaks were detected during the rest of the program, there were many instances of Titralog alarms caused by emissions interference during which the system functioned as designed both mechanically and in notification.

The Bowen spray dryer continued to operate without major downtime. Stack emissions remained above standard; work on the venturi scrubber was not scheduled to begin until installation of the west scrubber commenced.

Work continued on the west quench/scrubber system with completion scheduled for mid-October. The test plan for equipment shakedown was approved during September.

The container cut and scrape operation began in earnest in September. Ash barrelling and storage procedures were finalized and implemented. The Quality Assurance laboratory began its analysis of the ash material and started reporting mustard content results to the Mustard Demilitarization Directorate. Problems experienced with the cutting operation were that the torch flame was causing the ash to burn and emit sulfur oxides and smoke particles. Personnel operating the cutting stage were required to wear respirators and welder's goggles during operation of the torch. A fume hood was being designed to inclose the cutting stage since it became apparent that the water cascade paint booths did not have enough face air velocity to handle the noxious fumes emitted from the smoldering ash. To cope with this, the cutting operation was cut back until the installation of the paint booth extension could be fabricated. A bubbler was moved into the area to monitor for mustard vapor and the use of a water spray to quench the smoldering and cut down on emissions was authorized by the Mustard Demilitarization Director. Full-scale operations would begin during October with the installation of the paint booth fume hood extension.

Statistics for September:

T.C.'s drained: 186 H 120 HD

Bulk agent burned: 417,700 lbs

T.C.'s burned, lbs: 106 E / 15 W

Residue burned, lbs: 46,063 E / 2110 W

Average T.C.'s per day: 5.6 E / 5.0 W

Average residue wt. per T.C.: 434 E / 141 W

Downtime, total for month: 1250 min

Overall GPM through nozzles: 1.82 (Based on total available operating minutes)

Effective GPM through nozzles: 1.93 (Based on actual operating minutes)

5.3.10 OCTOBER 1973 (See Figure 5-5)

Mustard operation, Phase III, continued in a satisfactory manner. Residue containers were burned in both the east and west container furnaces throughout the month. Several changes in burning procedures were made during October. On 4 October, the shift engineer and foremen were authorized to eliminate the 15-minute period which the ton container spent in the cooling section of the furnace nearest the door. The west furnace maximum residue limit was increased from 1900 pounds to 2100 pounds gross weight before burning as a result of increasing confidence in the west furnace's capabilities, and also as a result of the growing lack of lighter weight containers. This 2100-pound limit equates to an approximate residue weight of 500 to 600 pounds actual. On 23 October, toxic yard personnel were requested to remove from storage all residue containers with an "as marked" residue of 1300 pounds or more. Those containers were to have the plug adapter (previously discussed) installed and were to be returned to the plant for attempted redrain. Containers were to be stencilled with red paint with the letter "R" to indicate a "reworked" container which had previously been drained to avoid confusion in drain data. Reworked containers after this second drain were then placed in the Building 538 storage yard for burning. The largest of these containers were saved for special handling toward the program's end.

The installation of the west quench/scrubber continued during October. On 1 and 2 October, the plant was not operational due to the installation of a brickwork wall in the furnace breeching which was fabricated to isolate the hydrazine furnace and the breeching immediately adjacent to it from the east scrubber system. This was done to reduce the amount of downtime incurred due to the tie-in of the west quench inlet duct. This was refractory lined circular duct which had to be connected to the furnace breeching immediately behind the hydrazine furnace. The isolation of this portion of the flue system allowed installation work to proceed concurrently with ton container incineration, thus minimizing downtime incurred. The duct installation was completed by 25 October and the hydrazine furnace was fired to allow for curing the duct's refractory lining. Debugging the west scrubber and portions of the scrubber test plan were performed during the last week of the month with the refractory breeching wall still in place. This wall was removed on 3 November for further system testing. The 1 to 2 October shutdown previously mentioned also permitted installation of a 90° round elbow to replace the 90° straight elbow left when the preheater was relocated. An inspection and washdown door was subsequently installed in the new 90° elbow section.

The ton container cut and scrape full-scale operation was resumed on 7 October with the completion of the paint booth fume hood extension. This operation was

paced at the rate of 16 containers per shift or 48 containers per day and was a fill-in operation which could be worked as personnel were available provided that the 48 per day minimum was met.

The Bowen spray dryer was shut down for modifications by Bowen. These modifications consisted, in part, of installation of a high energy venturi scrubber and a larger system driving fan to provide increased static pressure dictated by the high pressure drop requirements of the venturi (approximately 20 inches). The Building 540 Bowen dryer was down throughout October. The Building 536 Tailor dryer was operated during this month on an "as required" basis to draw down the brine storage tank levels.

During October, preparations were made to transfer personnel to the M34 Demilitarization project. This first transfer was to become effective on 11 November. A total of 24 individuals were to be transferred consisting of one engineer, two foremen, three leaders, and 18 operators. This work force was to constitute a training pool for the M34 operation's second shift.

Statistics for October:

T.C.'s drained: 13 H 6 HD

Agent drained: 38,892 lbs

Bulk agent burned: 0 lbs

T.C.'s burned, lbs: 120 E / 281 W

Residue burned, lbs: 61,370 E / 28,290 W

Average T.C.'s per day: 5.7 E / 13.4 W

Average residue wt. per T.C.: 511 E / 101 W

Downtime, total for month: 2775 min

Overall GPM through nozzles: 0 (based on total available operating minutes)

Effective GPM through nozzles: 0 (based on actual operating minutes)

5.3.11 NOVEMBER 1973 (See Figure 5–6)

Mustard Demilitarization operations, Phase III, continued in a very satisfactory manner. Residue containers were incinerated in the east and west container furnace throughout November with no procedural or weight limit changes. Winter shutdown procedure was implemented on 8 November and continued until the program's termination.

The only major equipment malfunction occurring during November was the failure of the motor coupling on the ESP exhaust fan on 18 November. This coupling failure necessitated 24 hours downtime while a replacement could be found and modified to repair the unit and resume operations. In the process of obtaining a spare coupling, it was discovered that one had not been ordered by the Maintenance Division. The Director of Mustard Demilitarization subsequently took over the ordering of spare parts and maintaining a spare parts inventory.

Testing of the west quench/scrubber system continued throughout November. The refractory bricking wall was removed on 3 November and tests were conducted on the west scrubber according to test plan, utilizing effluent from the ton container furnaces. During nontesting periods, the west system was isolated by means of the two dampers built into the system. These dampers worked very well in eliminating leakage through the nonoperational system. A similar damper had been installed in the east scrubber outlet duct just upstream of the preheater at the same time as that unit's relocation. This damper alone was not, however, adequate to prevent leakage through that system when it was closed down; consequently, acid-bearing leakage through the nonoperational scrubber later caused severe deterioration of the damper valve and the damper spool section. On Saturday, 10 November, the east quench tank inlet duct was disconnected from the tank and a blank plate inserted to seal the duct. This was necessitated by the condition of the east quench to scrubber duct which had deteriorated to the point where it was neither operationally nor structurally sound and posed a safety hazard to the operators. Replacement of this duct was a long process requiring repair of the quench outlet and scrubber inlet flanges as well. The west scrubber was judged satisfactory to assume an operational role; consequently, the west system was started up as the primary scrubbing system for ton container effluent on 12 November based on the results of the prior testing. Bulk agent effluent was passed through the west system for the first time on 12 November with quite satisfactory results. The west quench scrubber had proven to be far superior to the east system in dependability, ease of control, and operational stability. Further testing was suspended subject to the reinstallation of the east quench to scrubber duct.

The Bowen dryer modifications were completed during November. Subsequent system testing showed that while the modifications eased the opacity problem somewhat, the particulate emissions exceeded State of Colorado standards. Considerable difficulty was experienced with flame retention, temperature regulation, and scrubber brine regulation. This was the first of two fan changes, the initial fan did not provide the total head expected.

Statistics for November:

T.C.'s drained: 0 H 4 HD

Agent drained: 6164 lbs

T.C.'s burned, lbs: 134 E / 203 W

Residue burned, lbs: 67,145 E / 51, 915 W

Average T.C.'s per day: 6.4 E / 9.7 W

Average residue wt. per T.C.: 501 E / 256 W

Downtime, total for month: 2360 min

5.3.12 DECEMBER 1973 (See Figure 5–6)

Mustard disposal operations, Phase III, continued in a very satisfactory manner throughout the month of December. Minor downtime problems observed were similar to those occurring throughout the program. Ton containers were incinerated in the east and west container furnace throughout the month. A weight limit change was made for both furnaces on 3 December. The east furnace was to burn containers of between 2400 and 2900 pounds gross weight before burning only. This represents 900 to 1400 pounds of "actual" residue per container. West furnace limits were set at 1500 pounds to 2400 pounds which equated to 0 to 900 pounds residue. All containers of less than 2400 pounds were to be reserved for the west furnace only. Incineration of any container weighing in excess of 2900 pounds was to be approved by the Director of Mustard Demilitarization personally. An additional change to the burning procedures was to store residue ton containers in the thaw room starting on 20 December. The temperature in the thaw room was maintained at ambient since the steam heating was shut down on 17 December as an energy conservation measure with no T.C.'s remaining to be drained. The storage of containers in the thaw room was necessitated by the extended container burn times observed which were thought to be due to frozen agent.

Repair of the east quench to scrubber duct was completed during December. The remainder of the west quench/scrubber system test plan was performed following this reinstallation.

The Bowen spray dryer was operational on an "as required" basis throughout December. Cold weather during the month began to show up inadequacies in the spray dryer's winterization and heat tracing equipment. Frozen and cracked hoses, frozen pipes and stuck linkages were common problems. The spray machine also froze and its housing was cracked. This problem was caused by inadequate checkout of the cooling fluid. This unit was replaced with a spare and the damaged unit sent back to Bowen Corp. for rebuilding. Modifications to the spray dryer during December included a wider fan impeller designed to bring the system total head and volumetric air flow up to a level sufficient to enable the venturi to operate properly. Effects of this modification in terms of opacity were, on initial observation, very satisfactory. This was the second fan changeout.

Normal cleanout and inspection of the scrubber systems, ESP and furnaces were performed in December as they had been for the duration of the program. An additional weekly check was initiated when it was discovered that salt leaking past the packing on the compactor feed screw gear box was destroying the gear lubricant. On 8 December, this material was removed and the box repacked with lubricant. A weekly check of this lubricant was directed and carried out.

The first part of the Chemical Agent and Munition Disposal System (CAMDS) project testing was performed in the east furnace on 19 December. This consisted of incinerating HD containers retaining 400, 800 and 1200 pounds of agent under controlled burning conditions. Time used by this testing was 19.4 hours. Further tests were scheduled for January 1974.

Statistics for December:

T.C.'s burned, lbs: 104 E / 132 W

Residue burned, lbs: 61,681 E / 49,680 W

Average T.C.'s per day: 5.5 E / 6.9 W

Average residue wt. per T.C.: 593 E / 376 W

Downtime, total for month: 1290 min

5.4 AGENT OPERATIONS (1974)

5.4.1 JANUARY 1974 (See Figure 5–6)

The Mustard Demilitarization Program, Phase III, continued in January in a very satisfactory manner. Residue containers were incinerated in both the east and west container furnaces. There were no modifications either in procedural or weight limit aspects of the container burning operation. The ton container cut and scrape operation was continuing at an adequate rate with the number of containers cut and the number of containers incinerated approaching equality. Some difficulty continued with frozen brine lines which were located outside the winterization annexes. If the program were to last longer than March or April, serious consideration would have had to be given to redesigning the entire heat tracing system of the plant during the summer months.

CAMDS tests were conducted during January on burning agent and residue-filled 155 MM artillery projectiles. Empty projectiles filled with RMA agent and drained, residue-filled rounds from Tooele AD (also filled with RMA agent) were incinerated in the east furnace under controlled test conditions. A total of 13 operational hours were consumed for both container furnaces by this testing.

The Bowen spray dryer operated adequately throughout January. Some difficulty was experienced with the system drive fan balancing; this was corrected by Bowen.

Draining of reworked ton containers continued during January. A combination of the plug adapters in two holes of the containers and use of the newest unload booth, 1A, allowed additional agent to be drained from most of these containers, thereby reducing the heavy container load on the east furnace.

On 27 January, an examination of the damper spool piece on the east scrubber outlet duct revealed that the damper and spool piece had deteriorated to the point where they were causing significant loss of negative pressure to the system as a whole. A replacement spool piece was not available; therefore, the defective unit was removed and both ends of the gap blocked with caps. It was intended to replace this damper with a rebuilt or entirely new unit; this was not accomplished during the remaining month of the program.

At 0155 hours on Friday, 25 January, there was an accident which damaged the ESP. Two explosions occurred within the precipitator which caused minor damage to several of the unit's components. Damage was limited to an estimated $2200 and caused a maximum of 21 hours downtime to the facility. The plant was operational again at 0150 hours on Monday, 28 January.

Statistics for January:

T.C.'s burned, lbs: 124 E / 184 W

Residue burned, lbs: 63,148 E / 50,156 W

5.4.2 FEBRUARY 1974 (See Figure 5–6)

The mustard demilitarization program at RMA was completed on 20 February 1974 with the incineration of the last stockpile container not reserved for CAMDS testing. The last of these containers was incinerated, with press coverage, on 16 March 1974. There were no operational difficulties experienced during February. Notice of the termination of nontest incineration was conveyed to the Program Manager by message on 20 February 1974.[15]

The CAMDS projectile tests continued throughout February with a total of 71.4 hours attributable to testing. Modifications for HD CAMDS container testing were made to the east container furnace following the completion of stockpile container burning. This CAMDS testing was conducted on the day shift only.

Destruction of the so-called "88" containers was authorized in February and began immediately following the last of the nontest stockpile containers. The sampling of these containers was carried out during January. The contents of these containers were not specifically identified other than mustard content, organophosphate presence or absence, and heavy metal content. A plan for disposal was forwarded to the Program Manager who gave approval during February. These containers were drained as normal mustard containers and the resulting bulk material incinerated through the hydrazine furnace nozzle or bulk agent. Scrubbing of stack effluent was conducted as normal. All of the "88" containers were cut and scraped. Barrelling of ash, ESP residue, and salt from these containers was treated circumspectly since some five of the containers contained arsenic-bearing residue. Personnel protective clothing and area restriction during barrel loading operation were required for safety purposes.

Disposal of the "Lake A" ton containers was carried out during February. A report on this operation has been submitted under separate cover.

During February, USAEHA conducted their source sampling survey of the mustard spray dryer stack. Results indicated that the unit met both the opacity and the particulate emission rate standards of the State of Colorado when being fired with fuel oil or natural gas and when operating at 30 GPM. A representative of the State Health Department witnessed the USAEHA testing and concurred in the visual measurement of stack opacity.

Statistics for February:

T.C.'s burned, lbs: 56 E / 85 W

Residue burned, lbs: 36,115 E / 35,967 W

Average T.C.'s per day: 3.7 E / 5.7 W

Average residue wt. per T.C.: 645 E / 423 W

Downtime, total for month: 4599 min

5.4.3 MARCH 1974 (See Figure 5–6)

The "88" ton containers disposal program continued into March. The final container was incinerated on 15 March. The final container of the RMA mustard stockpile was incinerated with press coverage on 16 March. This event was communicated to the Program Manager by message on 19 March 1974.[16]

CAMDS testing was completed prior to 16 March.

Cleanup of the Mustard Disposal Facility began immediately following the incineration of the last residue ton container.

5.5 DOWNTIME ANALYSIS

Downtime recorded during the bulk agent incineration phases of the schedule refers to those problems which caused a cessation or curtailment of bulk incineration. Stoppages of the east container furnace operation was not recorded as downtime since, despite the fact that there was a daily container schedule, this operation did not become a pacing operation until Phase III. At that point, all of the downtime recorded was that which affected only both container furnaces simultaneously. Downtime occurring for each furnace individually was only recorded for special cases such as testing, and then only for study purposes.

The monthly downtime for the period August 1972 through February 1974 is presented in Table 5–1.

5.6 ENGINEER TEST AND IMPROVEMENT PROGRAMS

5.6.1 TON CONTAINER BURNING STUDIES

The initial work associated with the improvement of the demilitarization process by shortening the ton container residence time was begun during January 1973 with the assignment of a Chemical Process Engineer and a Data Analyst (both military) to the Product Division (later Mustard Demil Directorate) of the Directorate of Industrial Operation (later Chief Engineer's Office). A shotgun approach was taken at first to observe the relationship, if any, between the critical operating parameters used during the burning of residue ton containers. This shotgun approach utilized data as recorded by the operators in the plant for each container incinerated from 21 August 1972 to the date of the study. Several of the most useful parameters were defined as:

A. Residue Burned (RB) - The weight of residue actually burned out of the container based on gross weights measured before and after incineration.

B. Peak Temperature (PT) - The maximum temperature recorded on the furnace hot section thermocouple.

C. Residence Time - The time of residence of the ton container in the hot section of the furnace.

D. Residue weight from taring - Residue weight arrived at by assuming a standard tare weight of 1600 pounds for an empty ton container.

The relationship developed by plotting these parameters against each other were:

A. That residue burned appeared to be a linear function of residence time with the exception of container weights from 0 to 300 pounds. This indicated that a significant improvement could be made by redefining the burning condition of this residue weight group.

B. Peak temperature was a nonlinear but regular function of both weight of residue burned and residence time.

C. Correlations involving strict measurement data such as residue burned and peak temperature were much better defined than those utilizing residence time which was itself a function of the alertness and conscientiousness of the individual operators of the furnace system.

D. The validity of a 1600 pound tare weight assumed for each container in future studies was proved by the very closely grouped linear data plotted for residue burned versus residue from taring.

The result of this study was the realization that to arrive at a better definition of the critical burning parameters, a test should be conducted utilizing trained observers scrutinizing the around-the-clock incineration of containers in the 0 to 300 pound residue weight group.

5.6.2 THE DYNASCIENCES INSTRUMENT EVALUATION AND CONTAINER RESIDENCE OPTIMIZATION TEST - PHASE I

The objectives of this test were (1) to determine whether or not the Dynasciences (flue gas SO_2 monitor) instrument could be effectively utilized to shorten the residence time of ton containers and (2) to obtain an understanding of the interrelationship of the process parameters, specifically: Dynasciences response, observable burning phenomena, temperature, and pressure measurements. The test plan for this study was prepared on 7 February 1973[17] and forwarded to the Program Manager on 13 February 1973[18] along with a copy of the previously written test plan for the evaluation of the Gross burner configuration. This test had been suspended indefinitely in favor of the Dynasciences test and a slower approach to large residue weight container burning.

The Dynasciences test plan Phase I was to have handled containers with as much as 900 pounds residue weight. This was cut back to 300 pounds maximum with the investigation of larger residue weight burning to be postponed until May 1973. The Phase I test was to handle H type containers initially. A detailed exposition of the test as designed is contained in the referenced test plan.[19]

The test was performed in the period 12 to 26 February on a 24-hour basis. Data collectors were trained military personnel from the US Army Technical Escort Center's Escort and Disposal Detachment located at RMA. Details of the test as performed are contained in the test report published on 9 April 1973.

Major conclusions drawn from the test data were:

A. Dynascience instrument response did not provide the necessary reproduceability required to use the instrument as a basis for residence time optimization.

B. The parameter time to flameout (TFO) was observed to be much more predictable for a given residue weight and should be made the basis of optimization efforts. This parameter had been identified in the first shotgun data analysis of January 1973 as residence time.

C. A second phase of the optimization test would be required which would investigate the effect of sparging air variance unburning parameters and attempt to optimize container burning based on an extraction of a container from the furnace at an experimentally determined optimum time after flameout.

5.6.3 THE DYNASCIENCES INSTRUMENT EVALUATION AND CONTAINER RESIDUE OPTIMIZATION TEST - PHASE II

Following the recommendations and conclusion of the Phase I test, a plan was constructed on 26 March 1974[20] which incorporated two parts:

A. Part I - to determine the effect of different sparging air pressures on burning conditions for H and HD ton container.

B. Part II - to optimize H ton container burning time based on data from Phase I, Phase II - Part I, and analysis of mustard content of the residual ash.

The testing was to utilize time to flameout (TFO) as the basis for optimization of containers of less than 300 pounds residue. Details of the test plan are contained in the referenced test plan document.

The testing operation was begun during April 1973, but had to be postponed due to the erratic regulation of the ton container furnace temperature caused by the introduction of the bulk agent-burning hydrazine furnace. The test was to have been performed immediately after the ESP installation of 8 May but was superseded by a test on the east scrubber and the scrubber packing replacement on 23 to 28 May. The testing did resume, however, on 30 May and continued until 14 June on a 24-hour per day basis. The details of the performance of these tests are contained in the test report published on 12 July 1973.[21]

Conclusions of this Phase of the optimization test:

A. The residence time of each container in the 0 to 300 pounds residue weight group could be shortened significantly as a result of the application of the results of this test.

B. The reburn period for ton containers which tested positive after first incineration could be safely shortened from the standard 75 minutes to a total of 30 minutes. This was an outgrowth of a study conducted at the same time as Phase II but not contained in the test plan.

Implementation of the results of this test occurred on 26 June 1973 with the posting of a chart on the window of the T.C. charging cart,control platform. This chart[22] was based on the temperature rise experienced by burning off the agent and residue contained in each ton container. This temperature rise was correlated with the observed time of flameout. The selection of the data contained in the second column, the time that the container was to be extracted from the hot section of the furnace and moved to the cooling section, was based on the temperature rise versus time to flameout plot with a safe-siding of the data. The use of this table was supervised for the first week by process engineering observers operating on day shift. Following this trial period, use of the chart was unsupervised, except by checks of recorded data. It was necessary to remind the operating staff on several occasions to adhere to the new burning procedure; however, in general the procedure was well adhered to as evidenced by the more than significant increases in ton container production observed in subsequent months.

5.6.4 TEST PROGRAM FOR OPTIMIZATION OF LARGER RESIDUE WEIGHT TON CONTAINERS

The work described in the above paragraphs, while very significant, addressed only part of the problem. A potentially difficult problem remained in the form of incineration of ton containers of greater than 300 pounds of residue. A

projection of the number of containers in each 100-pound weight increment had been forwarded to the Program Manager on 2 July 1973.[23]

As a result of the above, a draft test plan for evaluating alternate methods of incinerating ton container of residue weight 300 to 1000 pounds was written on 28 June. This test was revised on 20 July[24] as a result of a meeting at Edgewood Arsenal on 19 July. This revision incorporated information to be taken for the CAMDS project as well as a provision for investigating the burning of containers beyond the 1000-pound maximum called for in the original test plan. There were two parts to the test program:

A. Part I was to determine the effect of varied burner configurations and temperature staging conditions on the burning characteristics of the previously observed 0 to 300 pounds residue weight range. This was intended to provide a basis for selection of those criteria which would most probably fit the desired burning characteristics of large weight containers.

B. Part II was to use the observations of Part I to determine the feasibility of burning containers of 300 to 1000 pounds and to optimize the experimentally determined burning procedure arrived at. Additionally, if considered feasible, the incineration of containers of greater than 1000 pounds was to be attempted. Details of both Parts I and II are contained in the referenced test plan document.

The testing was conducted over the period 26 July through 14 August and was performed on day shift only, because presence of the process engineer was required. This requirement was due to the potentially hazardous nature of the testing. A draft test report was written but never formally published; therefore, more detailed information is not available in final form. In general, the test was performed as follows:

A. Three burner configurations were explored for rapidity of burning within safe limits.

B. After a burner configuration had been selected for rapidity, this configuration was time-staged in an attempt to derive the quickest burning procedure.

The primary result of the heavy residue testing was that containers of as much as, and exceeding 1000 pounds residue could be safely incinerated utilizing an experimentally determined burning procedure which also optimized the residence time. This procedure was reduced to the form of a chart and placed next to the 0-to-300-pound weight range burn chart on the T.C. charging cart window on 14 August. The procedure developed was:

A. The furnace set point was to be 920°F as opposed to 1000°.

B. Insertion of the ton container into the furnace was to be performed with only top burner lighted.

C. After the furnace temperature had peaked, the burners were switched from top to bottom and the operators were to wait until the container had flamed out until moving it to the cooling section of the furnace.

This method was posted as a trial method and was refined on 28 August[25] and again reduced to a posted chart, replacing the 14 August chart. At the same time the improved lightweight burning chart was posted in place of the earlier chart.[26] The heavy T.C. method was refined to allow for an 800°F insertion temperature as opposed to 920°F. Bulk agent burn was to be continued throughout the T.C. peak burn at the discretion of the shift engineer or foreman. Some additional definition of which of the two or three temperature peaks normally observed was intended as the peak was required. A further change was made during Phase III when the larger draft afforded the T.C. furnaces by the cessation of bulk agent burn required that the lower burners be turned on for 5 to 10 minutes at the insertion of a heavy residue container to get it started quicker.

5.6.5 UPPER BURNERS IN WEST FURNACE

The installation of the upper burners in the west container furnace to duplicate the east furnace was requested by the Program Manager on 26 September 1973. A work order was generated for this project and the material put on procurement; however, the program was completed before installation could be accomplished. In any event, the west furnace's capabilities coupled with the installation of the west scrubber and the cessation of bulk burning, were improved such that containers of much larger residue weight than originally thought possible could be handled.

5.6.6 T.C. DRAIN STUDIES

Drain studies were made throughout the program for the varying purposes associated with schedule projections and T.C. burning studies. A summary drain study was performed at the end of the bulk agent burning phase of the program in order to review draining performance and provide an estimation of the number of containers of specific residue weight groups remaining to be burned. This summary is shown on Table 5–2.

5.6.7 UNLOAD BOOTH 1A, UNLOAD BOOTH HOSES

The new unloading booth 1A which was operational during August 1973 proved to be a much more effective piece of equipment for draining containers as indicated in Table 5–2 by the increased number of containers of the 1500 to 1800 pound agent drained group.

Unload booth hoses were directed to be changed once a month as of 27 March 1973 as a result of the mustard incident of 2 November 1972, in which a hose ruptured. A study of a hose used for one month was made in July 1973 and the evidence of deterioration was such that changeout every two weeks was directed.[27] A carbon-filled teflon-lined, flexible steel hose was tried out and rejected as was a plain, teflon-lined, flexible steel hose. Both were found to be unacceptable due to cracking and kinking when bent at too sharp an angle. The butyl rubber hoses were retained and changed out every two weeks, as prescribed, with no further problems.[28]

5.6.8 HYDRAZINE FURNACE TESTING, TEST H-1

Methods for upgrading the bulk agent burning capabilities of the disposal system were continuously being explored. An RMA suggestion to modify the hydrazine furnace to incinerate bulk agent was adopted and the required modifications carried out. On 12 February, a test plan[29] was published which covered the startup of this modified furnace. The burning of bulk agent was to be approached cautiously. Test H-1 was an optimization of burning conditions on fuel oil at approximately 0.5 to 1.0 GPM in an attempt to simulate the heat input of agent at 1.0 to 2 GPM (number 2 fuel oil has approximately twice the heat content per pound as pure agent).

Startup on fuel oil gave the opportunity of adjusting controls and learning the furnace's idiosyncracies without being confronted with a potential contamination problem. Details of the performance of this test are contained in the test report published 19 March 1973.[30] Several minor problems dealing with the control system were observed and corrected. A major problem which occurred was an overheating of the noninsulated front face of the furnace. This overheating caused some buckling and scorching of the steel front face of the furnace. This front face had been left unbricked for access to the furnace barrel, and was not expected to overheat since a greater amount of dilution air for cooling was expected to be drawn from the tank pit ventilation duct and from dilution air ports on the front of the furnace. These sources had to be maintained essentially shut, however, to provide as much furnace draft as possible. The heating problem was solved by installation of a firebrick wall around the combustion chamber; in effect capping the furnace barrel and insulating the front furnace face from the majority of the heat in the furnace. Two 12-inch diameter iron pipe dilution air intakes were installed on a diameter in this wall; thus allowing whatever dilution air to circulate and keep the front furnace face cooler.

Test H-1 proved the capability of the hydrazine furnace for agent incineration at the 1 GPM rate and indicated that a 2 GPM rate could conceivably be maintained with little operational difficulty. Additionally, it was learned that ton containers of moderate residue weight could be incinerated without stopping the agent flow during peak residue burn.

5.6.9 HYDRAZINE FURNACE TESTING, TESTS H-2 THROUGH H-4

As a follow-on to test H-1, tests H-2, H-3, and H-4 were designed to:

A. Burn HD at 1 GPM with no simultaneous T.C. burning.

B. Burn HD at 1 GPM with simultaneous T.C. burning.

C. Burn H/HD feed at 1 GPM without homogenizers to observe nozzle plugging potential of normal feed.

D. Burn H/HD feed at 1 GPM with homogenizers.

The test plan for H-2 through H-5 was contained in the same document as H-1.

Testing occurred during the period 19 March through 2 April 1973. A detailed presentation of the test results is contained in the test report published on 19 April 1973.[31] Tests H-2 through H-4 were accomplished successfully with none of the problems experienced during the early part of Test H-1. Mustard feed rates tested during the first operational week varied from approximately 0.9 GPM to 1.6 GPM, based on shift averages. Feed rates during the second operational week of the test period ranged from 1.2 GPM to 1.9 GPM with an average of 1.6 GPM. Ton containers were burned at the same time as bulk agent with no cessation of bulk agent burning for either T.C. incineration or peak residue burn. The ratio of H to HD mustard varied from 0 to 4.96 during the first week and reached a maximum of 13.6 during the second week. No nozzle plugging was experienced during this test period. Subsequent operational ratios of H to HD approached the point of essentially pure H type agent with no nozzle plugging and only minor flow control valve plugging.

Successful completion of test H-4 allowed the furnace to be certified for agent service and its operational use began immediately after the completion of H-4.

The agent nozzle was removed for inspection after approximately three continuous weeks of operation; little deterioration was observed other than a slight enlargement of the orifices in the head of the nozzle. These nozzles gave exceptional service throughout their use on bulk agent. Flow control valves had to be changed out approximately once a month due either to plugging or erosion of the valve seats.

5.6.10 HYDRAZINE FURNACE OPERATING CONDITIONS

The normal operating procedure and set points for the furnace were the result of experience and material limitations. During 2 GPM burning, the flow rate of agent was regulated by a combination of combustion air input, natural gas input, furnace draft, and stack temperature. The furnace refractory material could withstand 3300°F; however, this high temperature capability was never utilized since the breeching refractory could withstand only 2200°F. This material limitation became the governing temperature of the furnace. Agent was fed in at as great a rate as would not cause the 1900°F set point on stack temperature to be exceeded. This set point was selected based on a 300°F safety factor on the maximum stack temperature.

The agent burn rate was thus a function of the amount of cooling air that could be forced into the furnace by the combustion air fan. The damper on this fan was normally run barely opened in order not to overpower the furnace draft which was, ultimately, the limiting factor on the furnace. A furnace negative pressure of 0.1 inches of water was normal at the 2 GPM burn rate; under furnace idling conditions, with no agent, but just enough natural gas to maintain the normal furnace barrel temperature at 2200 to 2300°F and the normal combustion chamber temperature at 2400 to 2500°F. A steady operating differential pressure of slightly more than 0.4 inches of water was possible when no T.C. furnaces operated.

Natural gas input was normally cut back to a pilot flame for reignition in event of a problem which would snuff out the agent flame. This event did not occur; therefore, it was not determined if the pilot flame was even necessary given the normal incandescence of the combustion chamber refractory.

The operation of the west quench tank indicated that a breeching temperature of 2000 to 2200°F could have been authorized if these temperatures were required for the combination of maximum burn rate and differential pressure,

5.6.11 EAST SCRUBBER TESTING

A test was performed on the east quench/scrubber system immediately after the installation of the new ESP. The test was designed not only to check out the operating characteristics of the precipitator but to determine whether maximum air flow rate through the newly configured system would cause either loading or flooding of the packed column scrubber. The test was performed and it was determined that the scrubber would not approach the loading point. However, repacking the scrubber on 23 May 1973 caused a reevaluation of the data.

5.6.12 WEST SCRUBBER TESTING

A test program was prepared on 15 August 1973 for the evaluation of the mustard disposal system following installation of the west scrubber system.[32] The purpose of the testing was to determine the operating characteristics of the west quench/scrubber, to evaluate the system air flow distribution, and to establish the system capability under several possible furnace input configurations and bulk/ton container burn sequences. Details of the test plan are contained in the referenced document.

Tests S-1 through S-5 were performed between 23 October and 12 November 1973. The testing was interrupted by the shutdown of the east scrubber system on 10 November. All of the remaining portions of the test were eventually completed.

The results of the testing were that the west scrubber system was found superior to the east system both in capacity and stability. The west quench could easily handle the normal temperatures of the hydrazine furnace as well as the combustion products from 2 GPM mustard burn. This was in conjunction with the operation of both T.C. furnaces with simultaneous T.C. peak burns.

5.6.13 BOWEN SPRAY DRYER TESTING

Details of the major problems with the Bowen spray dryer unit are contained in a series of memoranda from the Director of Mustard Demil for the record.[33] These documents give the full history of the unit's modification to correct certain design or equipment problems which occurred during the operation of the unit during the period 9 March to 30 November 1973.

The first evaluation of the spray dryer bv USAEHA occurred during the period 7 to 20 June 1973.[34] This source emission evaluation concluded that the visible and particulate emissions were greater than the levels established by the air pollution control regulations of the State of Colorado when the unit was operational at production load conditions. Additionally, visible emissions were excessive when the unit was operated at minimum load conditions. These results prompted the modifications by Bowen which eventually eliminated the solution of the emissions problem.

Data presented by Lear-Siegler Inc. (LSI) during their evaluation of 4 April and 5 June[35] support the USAEHA test results. LSI utilized an optical transmissometer which was stack-mounted and measured in-stack opacity.

Final Army acceptance testing occurred during 1 to 7 February 1974 when USAEHA performed a second set of source emission tests on the spray dryer unit.[36] The conclusions of this survey were that when the unit was fired with fuel oil, the opacity and particulate emission rate were less than the level of the State of Colorado standards as long as design specifications were not greatly exceeded.

5.6.14 ELECTROSTATIC PRECIPITATOR TESTING

Preliminary ESP testing was performed informally after its installation in early May 1973. This testing consisted of an equipment shakedown and demonstrated the satisfactory performance of the unit in terms of mechanical operation and visual emissions.

On 6 June, Lear-Siegler performed a stack survey with their optical transmissometer[35] which indicated that at maximum system disposal rate the ESP in-stack opacity was measured at 3 percent with 3 stages operating and 5 percent with 2 stages operating. This stack opacity measurement was carried out under contract as a preliminary to the USAEHA acceptance testing of the equipment.

USAEHA acceptance testing of the ESP occurred during the period 20 to 25 August 1973.[37] Results of this testing indicated that the particulate emission rate met the State of Colorado's standards. Stack opacity was observed to be less than 5 percent which also met the State's standard. Those results were obtained with three out of the five stages running.

5.7 DISPOSAL OF END PRODUCTS

5.7.1 TON CONTAINER ASH AND ESP RESIDUE

Disposal of ton container ash and ESP residue was accomplished by dry land dilution on Arsenal property during July and August 1974. This was material collected from the ton container cut and scrape operation of September 1973 to February 1974 had been barrelled and stored in warehouses on the Arsenal. This storage occurred only after the ash had been sampled for agent content and cleared by Quality Assurance. The ESP residue had been collected from the precipitator

stages during the weekly cleanout of the equipment. The drums of this material, after sampling the residue for agent content; were placed in storage along with the ton container ash. Previous (before 1 May 1973) disposal of this material was by dumping in the RMA sanitary land fill by direction of the RMA Chief of Quality Assurance.[38]

The initial study of the feasibility of ton container ash disposal was made in April 1973 as a result of the 1 to 2 March 1973[39] program review meeting at RMA. The original work on this project was patterned after the Beal Air Force Base, Ft. Detrick and RMA land dilution projects for TX ash disposal. TX was a wheat rust that was destroyed by burning. It was realized at this time, that a more detailed elemental analysis of the ton container ash was required than was currently available. Arrangements were made with Coors Spectro Chemical Laboratories, Golden, Colorado, to do the analysis within several weeks time. A preliminary estimate of acreage required was 78.9 acres based on an assumed dilution rate and an estimated ash production. A more accurate cost/time analysis was to be prepared and sent forward for approval.

Following receipt of the Coors ash analysis, preliminary calculations were made of soil elemental content after ash dilution.[40] These calculations used the Coors results, an assumed dilution rate of ash to soil, and the soil analysis from the TX ash dilution project. The estimate of 79 acres previously arrived at remained valid. Further effort on the dry land dilution project awaited a decision from the Program Manager to proceed. If this decision was forthcoming, a plot would be selected and an elemental analysis obtained on soil samples from this ground area.

Permission to proceed with the dry land dilution project was received from the Program Manager on 1 August 1973.[41] This communication authorized RMA to select a site and obtain soil samples tor elemental analysis. The Program Manager also directed that the iron and phosphorus content of the ash be determined by the RMA Quality Assurance laboratory to supplement the data in the Coors elemental analysis of the ash. Dilution criteria established in this letter were that the material was to be uniformly mixed to a depth of six inches, and that the concentration of any element in the soil was not to be increased by more than 0.05 percent or two parts per million by weight. A high confidence cost/time estimate and plan were requested.

A reply to the 1 August letter from the Program Manager was prepared by RMA and forwarded on 11 October 1973.[42] The results of soil samples taken from the plot of land selected, a portion of the northeastern-most square mile section of the Arsenal property, were presented along with the iron and phosphorous results requested. A recalculation of the after-dilution elemental concentration of the soil was presented. Two elements, iron and sulfur, exceeded the 0.05 percent criterion established, but these were determined by RMA to be nondetrimental constituents of the soil. A plot size of 79 acres was still calculated but a safe-sided plot size of 120 acres was recommended.

Concurrence in the interim plan presented by RMA on 11 October was received from the Program Manager on 29 October 1973.[43] This correspondence also contained the requirement for a detailed plan and Environmental Assessment Statement (EAS)

to be included in the same document. An additional requirement placed on RMA was the study of the dry land disposal of the electrostatic precipitator residue and preparation of a plan and EAS for the same.

The draft Plan and Environmental Assessment Statement for the Disposal of Ton Container Ash and ESP Residue by Dry Land Dilution was prepared during March and April 1974 and completed on 1 May 1974.[43] This plan was approved by message on 29 May[44] and operations were authorized to begin. The plan called for dilution of the ton container ash over a 120-acre plot in the previously selected southwest corner of the northeastern-most square mile section of RMA. The material was to be disposed of by spreading over the ground, plowing it in to a depth of 6 inches, discing the area to mix the soil and ash, and finally sowing the area with a cover crop after verification of the iron content of the resulting soil/ash mixture. The disposal rate of this material was to be 1452 pounds per acre which gave a dilution rate of one pound of ash per 1500 pounds of soil. The ESP residue was to be treated in a similar manner on a 320-acre plot adjacent to the ash residue plot. The distribution ratio of ESP residue was 2100 pounds per acre or one pound of residue per 1000 pounds of soil. These ratios were dictated by the necessity of meeting the 0.05 percent criteria established by the Program Manager in October 1973. Disposal of the ash and residue was scheduled to take 30 working days based on a 10-acre per day rate. Cover crop sowing would be simultaneous with ash distribution after an initial content of the first ash container area done. Details of the plan are contained in the referenced document.

The actual EAS sent forward by the Program Manager for approval was a shortened version of that contained in the referenced Plan and EAS document.

The plots were surveyed and staked by RMA Facilities Civil Engineering Section during June 1974. The staking was done by transit and comprised siting the four corners of each of the two plots. The plots themselves were further subdivided into 10-acre increments by the Special Projects personnel carrying out the operation. Actual ash disposal began on 8 July 1974 and was completed on 7 August 1974. A total of 23 working days were consumed, yielding an average of 9.6 acres per day, well within the estimated rate. The operation was not hampered by bad weather since the summer was unusually dry. A total of 222,063 pounds was distributed by actual weighing of each residue drum. The residue was mostly wet material as a result of the water which had been used to eliminate noxious emissions during the container cut and scrape operation. The ash drums were found to be badly deteriorated for the most part. They were washed and turned into Property Disposal for salvage.

Dispersal of the ESP residue followed the ash operation immediately. An extra 22 acres over the 32-acre estimate were required for the residue dispersal. The operation began on 8 August and terminated on 16 August 1974 consuming 7 operating days for an average of 7.9 acres per day. A total of 63,158 pounds of residue were spread over the ESP residue plot. This rate was 2.1 acres per day less than the estimated rate; the entire operation was performed within the 30 estimated days, however. This meeting of schedule was the result of highly effective work by the 12 enlisted

personnel assigned to the project. Vigorous supervision and leadership under adverse conditions resulted in a utilization of manpower and machinery on a level far beyond the already well-demonstrated best efforts of the Special Projects Division.

Difficulties experienced during the ash disposal were:

A. Material clinging in the spreader due to a wet consistency.

B. Foreign materials such as rags and spray paint cans contained in the ash jamming or damaging the ash spreader.

C. Difficulty in calibrating the ESP residue spreader due to the powdery consistency of the material.

Cover crop sowing proceeded as planned with the exception that a portion of the acreage had to be sown with millet rather than sorghum due to the low commercial supply of the latter. A portion of the crop germinated despite the almost drought conditions occurring toward the end of the summer. The material which did germinate did not bear fruit. Some of the material remaining as ungerminated seed will sprout in the spring of 1975. The prolific growth of weeds resulting from the spring rain will quickly cover the plowed area.

Permanent metal stakes with die stamped metal signs bearing the designation of the project, the material disposed of, and the date were implanted on each of the four corners of both plots. Photographic records of the project, including aerial photography, were made by the Edgewood Arsenal Technical Photographic Division, Photographic Science Branch (SAREA-TS-P), to preserve a permanent record of the location of the treated land area.

5.7.2 TON CONTAINER HALVES

Ton container halves were sold as scrap steel by RMA Property Disposal. The containers were carried from the disposal facility by truck to the Arsenal salvage yard after verification of absence of agent in the ash of each lot of containers. To give the laboratory personnel an adequate response time, the containers were held, after cutting, for 48 hours in the Building 538 storage yard.

5.7.3 CONTAMINATED METAL AND TRASH

All scrap metal suspected of contamination was incinerated with the contaminated trash in the container furnaces at the rate of one container per shift. The burning vehicle was a ton container with the top 30 percent of its circumference (except for the ends) cut off with a torch. It was modified with angle iron to accept the centrifugal agent pump and the agent tank homomixers when these were replaced and had to be thermally decontaminated. Duration in the furnace was a matter of experience. A cooled-down load of metal or a deconned piece of equipment was sampled with a blue band tube by a Quality Assurance inspector prior to release to the Arsenal salvage yard. All such material was tagged as xxxxx decontaminated in accordance with appropriate regulations.

Trash burning was limited to agent contaminated clothing, other agent contaminated combustible materials and DS2 decontaminant cans. Replaced unload booth hoses and rubber gloves were incinerated as well. Since each container of trash burned represented a period of nonproductive time for the furnaces, considerable emphasis was placed on strictly limiting the burning of trash to the materials described. All other material was disposed of by the Arsenal Roads and Utilities personnel as normal trash after being checked and tagged by a Quality Assurance representative.

5.7.4 SALT DISPOSAL

The salt generated by the mustard disposal process was placed in drums and stored in warehouses on RMA. Several attempts have been made to dispose of the salt by sale or by use on the roads of the Arsenal during winter weather. This latter approach was abandoned before it could be implemented as a result of a letter from the State of Colorado Department of Health[45] on 24 August 1973 advising against road use due to the high degree of solubility of the salt constituents and the sodium sulfate noncompatibility with concrete. This communication was forwarded to the Program Manager on 5 September 1973 by the Mustard Demil Directorate.[46]

Various attempts to sell the material were made throughout the duration of the program as listed by a memorandum for record furnished to the Program Manager on 22 January 1974.[47] There were no affirmative replies received. The material remains in storage at Rocky Mountain Arsenal as of this writing pending the results of further work on disposal by the Program Manager's Office.

5.8 PRODUCTION SAFETY PROBLEMS

5.8.1 MUSTARD EXPOSURES TO PERSONNEL

A total of four confirmed exposures of personnel to mustard agent were recorded during the demilitarization program from August 1972 through February 1974. One exposure occurred during plant cleanup, but was not directly relatable to the plant layaway operations.

A. Mustard Exposure, 2 November 1972

On this date, at approximately 0305 hours, the crew working on agent transfer operations was transferring agent from a ton container to the mustard storage tanks utilizing unload booths 1 and 2. An incident occurred when one of the flexible rubber hoses in Booth No. 2 ruptured, spraying a fine aerosol of agent around the baffle located between the unload booth door and the door seat and also through the points where the remote handles of the unload booth valves extended through the booth wall. This agent spray contaminated two operators who were given immediate first aid and taken to the toxic exposure aid station. The hose was determined to have ruptured as a result of a combination of agent pressure and deterioration. Most of the liquid agent was contained in the unload booth. A much larger agent spill was prevented by prompt action of the remainder of the unloading crew in closing the container

valves. This incident resulted in a recommendation which was immediately adapted which prescribed a monthly hose changeout. A further recommendation was that the design of the unload booths be changed to provide more operator safety. In the interim, more stringent protective clothing requirements were implemented when booths No. 1 and No. 3 were used for transfer operations. The use of booth No. 2 was discontinued indefinitely due to the loose door fit and the cutout portion of the door seat baffle which had originally allowed the agent to escape the booth. A subsequent modification was also made to the plant's deluge shower system when heaters were installed to bring the deluge water temperature to a more comfortable level.

B. Mustard Exposure, 3 January 1973

On 3 January 1973, at approximately 1745 hours, the crew working on agent transfer operations in Building 537 was preparing to transfer mustard from the west storage tank to the east storage tank. When this operation had been completed, it was noticed that the high liquid level alarm light for the vacuum dropout potentiometer lighted. The dropout potentiometer was pressurized by the operations with plant air to transfer its contents to the east storage tank. A resultant pressure buildup in the agent storage tank forced mustard up the centrifugal pump causing a leak at the packing gland. The agent dropped into the storage pit and circulated to the surface of the east storage tank. The tank pit space heater aerosolized the agent and forced it onto two operators working on the dropout potentiometer. Their congo red dye impregnated coveralls turned blue where they had come into contact with the liquid mustard droplets. The agent had reacted with the XXCC3 impregnite in the overalls causing a localized acidic product which turned the congo red indicator blue. Both operators showered thoroughly and applied M5 ointment to the affected areas. The leak was decontaminated with DS2 by personnel in Level A clothing. Subsequent modifications to the system were the removal of the air supply from the dropout potentiometer to preclude a reoccurrence and installation of a deflector on the space heater to prevent its blowing directly toward the entrance door of the tank pit.

C. Mustard Exposure, 10 July 1973

On 10 July at approximately 1100 hours, three maintenance men dressed in Level A protective clothing were engaged in replacement of a mustard pump. During this operation, the plastic bag used to enclose the pump being removed from the storage tank leaked, spilling agent on the steel deck adjacent to the transfer pump. The spill was immediately decontaminated with DS2. At approximately 1430 hours, the electrician assigned to reconnect the pump motor wiring entered the area to perform his work. The electrical hookup of the pump took approximately 15 minutes. During this period, the man worked in the area where the mustard spill had occurred. The area was subsequently washed down with water at 1600 hours. Later that evening, the electrician noticed a reddening of the area behind his left knee and reported to the Toxic Aid Station at 0900 the following morning. Modifications resulting from this

incident were: (1) Use of a heavier fabric reinforced nylon material, sewn into bags, for containment of agent pump or homomixers removed from the tanks, and (2) the installation of a permanent hoist in place above the centrifugal pump for ease of replacement.

D. Mustard Exposure, 20 September 1973

On 20 September 1973, at approximately 0815 hours, an electronic instrument repairman wearing congo red coveralls and gloves was engaged in replacement of a defective airline pressure gauge servicing mustard unload booth No. 1A. During this operation, an air/oil mixture was sprayed on the man as he removed the defective gauge. The man showered and changed his clothing after installing a new gauge. During the evening, and following morning, the man noticed a redness on his neck followed by appearance of small blisters. He was sent to the Toxic Aid Station by his supervisor when he reported for work on 21 September. The exposure was determined as caused by mustard dissolved in the oil contained in the airline. The position of the pressure gauge resulted from unsatisfactory design, in that it provided a trap for agent-containing oil. The maintenance man neglected to bleed the airline after shutting it off, and prior to starting repairs. An examination of the oil from vital points in the unload booth air system indicated that at some time agent vapor had backed up into the airline and contaminated the oil. Modifications to the air supply to the unload booth included installation of check valves to preclude an agent vapor backup and installation of in-line filters to remove contaminated oil from the air system. The air supply was to have been considered contaminated from the time of this exposure.

E. Mustard Exposure, 25 April 1974

On 25 April 1974, at 0800 hours, two maintenance men entered the disposal facility to repair a broken underground tile pipe in the chemical sewer line running from Building 742 to Basin A. One individual entered a manhole in the Building 538 storage yard which gave access to the section of sewer line above the damaged section. This individual placed a sandbag in the pipe section to block water flow and facilitate repair work. There was no odor of mustard agent noticed by either maintenance man. The maintenance man in the hole was wearing a protective mask, rubber boots, rubber gloves and nonimpregnated coveralls. While in the hole, he stirred up the four to five inches of sludge in the bottom of the sewer line. Upon leaving the sewer he suspected contamination and placed his clothing in a plastic bag for analysis. This analysis indicated positive agent contamination. The individual was informed of this and did not seek medical aid despite the warning and the observation of a reddening of the skin in the area above both knees; he eventually went to the Toxic Aid Station at 2015 hours of the same day. Neither of the maintenance men had informed the mustard demil shift supervisors of their actions in the Building 538 yard sewer; thus, this lack of appropriate protective clothing went unnoticed. Samples taken from the sewer sludge indicated a high agent content. Approximately 800 pounds of STB were

dumped into the hole and agitated to attempt a superficial decontamination of the area directly beneath the manhole. Complete decontamination of the sewer line was beyond the resources of the Arsenal at the time, and the task was therefore deferred until the Arsenal cleanup effort. There were no system modifications as a result of this exposure since it occurred during the cleanup phase. The incident is not related to the disposal program except to the extent that it occurred within the disposal facility. The source of the agent was unknown, but was suspected to have come from Building 742 during mustard artillery projectile filling operations in the early 1950's.

5.8.2 MUSTARD SPILLS

The only major spill which occurred during the demilitarization program occurred on 23 July 1973. At 0015 hours, during startup of the mustard facility, two personnel performing first entry monitoring of the thaw room observed that mustard had leaked around one of the valves of a ton container. All of the agent was observed to be contained in the thaw room. The fire prevention division was called to the plant and after investigating the situation, the assistant fire chief elected to implement portions of the Chemical Accident/Incident Control Plan. Personnel to implement this plan were called and arrived promptly. A hot line was set up outside of Building 537. The leak was stopped by rotating the T.C. to a position which had the leaking plug in the container's void space. The estimated 1100 pounds of agent spilled on the floor and sprayed on the walls was decontaminated by crews working in relays. STB slurry was used to decontaminate surface contamination. The bulk of the agent was covered with STB and subsequently hosed into the thaw room ventilating trench from which, after the addition of more bleach and after steam sparging, the agent-containing solution was pumped to the Building 536 brine storage tank. Caustic was added to the storage tank and to the trench. The brine storage tank was recirculated until QA laboratory analytical results showed no agent content in the brine. The material was then spray dried. The affected container was taken to the unloading booth, drained, and removed to Building 538 for incineration. A study of the plugs removed from the container after incineration revealed that of the six container plugs, three were brass plugs which had deteriorated to the point where the leaking plug had been held in place by two threads. The other two brass plugs were not as badly deteriorated, but could still be considered unsound. In general, decontamination procedures were correctly applied in drying the agent spill. There were no exposures resulting from the cleanup operation and the plant was back in operation at 1600 hours, on the same day. This spill prompted the installation of the remote weekend alarm system which was installed in September.

5.8.3 PROCESS EXPLOSION

A. There was only one instance of equipment damage during the program which was not associated with a routine equipment failure. This damage occurred on Friday, 25 January 1974, when at 0155 hours, there were at least two distinct explosions in the electrostatic precipitator. These explosions caused moderate

damage and resulted in a shutdown of the facility to repair the unit. Damage was confined to a ruptured seam in the expansion joint between stages 2 and 3, sheared catwalk bolts, popped insulation securing rivets, and cracked the grating at the foot of stage 2's support columns. None of the damage was structural in nature. A total of 17.75 hours of operation were lost due to repairs. The plant was operational again for normal startup on 28 January 1974.

B. It was concluded from an examination of the data that the explosions were probably caused by unburned mustard vapor, fuel oil, other combustibles (perhaps natural gas from the preheater) or a combination of any or all which had escaped the furnaces, passed through the west scrubber, and thence into the precipitator where an arcing cycle prompted the incident. The preheater had not been operating properly for some time, and had it been inactive during the time of the incident, it was believed that the combustibles would have been consumed in the flame.

C. Repairs constituted 94 manhours of effort and cost aprpoximately $2200 in labor charges. There was no schedule impact. A more complete discussion of the details of this occurrence is contained in the Memorandum for Record prepared on 31 January 1974[48] for decontamination.

REFERENCES

[1]RMA, TWX to MUCOM, dated 27 Jul 1972, subject: "Incineration of Mustard".

[2]RMA, (SMURM-O-P) Memo to Safety Office, dated 3 Apr 1973, subject: "Justification for Additional Ton Containers in the Thaw Room".

[3]RMA Letter to Munitions Command, dated 26 Apr 1973, subject: "Use of Hydrazine Nozzle in Ton Container Furnaces".

[4]Project Manager Letter (AMXDC-O) to RMA, dated 10 Jun 1973, subject: "Use of Hydrazine Nozzle in Ton Container Furnaces".

[5]RMA Letter to Precipitair Pollution Control, dated 9 May 1973, subject: "Contract DA AA03-73-C-0035".

[6]RMA Letter to AMC (AMCSF), dated 14 May 1973, subject: "Operating Limits of One-Ton Containers in Building 537, Mustard Demil Facility".

[7]AMC Second Indenture (AMCSF-N) to DDESB, dated 29 May 1973, subject: Same as above.

[8]DDESB Third Indenture to AMC, dated 11 Jun, subject: Same as above.

[9]AMSMU-SF Fifth Indenture, dated 12 Jun 1973 to RMA, subject: "Revised Mustard Unload Procedure".

[10]AMXDC-O Letter to RMA, dated 24 Aug 1973, subject: "New Unload Booth".

[11]RMA Letter to Program Manager, dated 27 Aug 1973, subject: "Ton Containers that cannot be Emptied in the Mustard Plant".

[12]Safety Memo to Mustard Demil Director on 27 Aug 1973, subject: "Safety Precautions Relating to Use of Mustard Ton Container Valve Adapters".

[13]RMA Letter to PM, dated 4 Sep 1973, subject: "Remote Alarm for Weekend Thaw Room Monitoring".

[14]RMA Mustard Director Memo to Security and others, dated 28 Sep 1973, subject: "Thaw Room Visual Alarm".

[15]RMA, TWX to Program Manager, dated 20 Feb 1974, subject: "Mustard Demilitarization Program".

[16]RMA, TWX to PM, dated 19 Mar 1974, subject: "Mustard Demilitarization Program".

[17]RMA Test Plan titled, "Test Program for Evaluation of Dynasciences Instrument and Optimization of Ton Container Residence Time", dated 7 Feb 1973.

[18]SMURM-O-P, First Indenture to PM, dated 13 Feb 1973, "Mustard Demilitarization".

[19]RMA Test Report titled: "Report on Test Program for Evaluation of Dynasciences Instrument as applied to Optimization of Ton Container Residence Time", dated 9 Apr 1973.

[20]RMA Test Report, titled: "Test Program for Evaluation of Dynasciences Instrument and Optimization of Ton Container Residence Time, Phase II", dated 26 Mar 1973.

[21]RMA Report titled: "Report on Ton Container Incineration Optimization Test Phase II: Parts I and II", dated 12 Jul 1973.

[22]Ibid, p. 69.

[23]RMA Letter to PM, dated 2 Jul 1973, subject: "Reply to Directed Action".

[24]RMA Test Report titled: "Test Program for Evaluation of Alternative Methods of Incinerating Ton Containers of Residue Weight 300 - 1000 Pounds", dated 20 Jul 1973.

[25]RMA Instruction Sheet titled: "Instructions for Heavy T.C. Burning", dated 28 Aug 1973.

[26]RMA Instruction Sheet titled: "Instructions for Burning Light T.C.'s", dated 28 Aug 1973.

[27]SMURM-M Letter to PM, dated 18 Jul 1973, "Hoses for Unload Booth".

[28]SMURM-QA-I & V DF to Mustard Director, dated 13 Jul 1973, "Inspection of Mustard Transfer Hose after One Month's Usage".

[29]RMA Test Plan titled: "Test Plan for Startup of Hydrazine Furnace to Burn Mustard at 1 GPM", dated 12 Feb 1973.

[30]RMA Test Report titled: "Report on Test H-1, Startup of Hydrazine Furnace on Number 2 Fuel Oil", dated 19 Mar 1973.

[31]RMA Test Report titled: "Report on Tests H-2, H-3 and H-4; Incineration of Mustard in Modified Hydrazine Furnace", dated 19 Apr 1973.

[32]RMA Test Plan titled: "Test Program for Evaluation of the Mustard Disposal System Following Installation of the Redundant Scrubber", dated 15 Aug 1973.

[33]RMA Memo for Record, titled: "Bowen Spray Dryer Status", dated 8 Mar 1973, 9 Mar 1973, 13 Mar 1973, 27 Mar 1973, 29 Mar 1973, 2 Apr 1973, 5 Apr 1973, 6 Apr 1973, 27 Apr 1973, 2 May 1973, 31 May 1973, 7 Jun 1973, 9 Jun 1973, 30 Nov 1973.

[34]USAEHA-EA Letter to RMA, dated 14 Sep 1973, "Source Emission Evaluation of the Mustard Spray Dryer".

[35] Lear-Siegler Inc Letter to RMA, dated 13 Jul 1973, Opacity Test Results.

[36] USAEHA-EA Letter to RMA, dated 26 Feb 1974, "Source Emission Evaluation of the Mustard Spray Dryer".

[37] USAEHA Letter to PM, dated 19 Nov 1973, titled: "Air Pollution Engineering Source Sampling Survey No. 99-013-70/74, 20-28 Aug 1973".

[38] SMURM-QA Memo for Record, dated 25 Dec 1973, "The Removal of Debris from the Mustard Area".

[39] SMURM-OP Letter to MUCOM, dated 27 Apr 1973, "Response to Directed Action".

[40] SMURM-M Letter to MUCOM, dated 19 Jun 1973, "Dry Land Dilution".

[41] AMXDC-O Letter to RMA, dated 1 Aug 1973, "Dry Land Dilution".

[42] AMXDC-O Letter to RMA, dated 19 Oct 1973, "Dry Land Dilution".

[43] RMA Plan titled: "Environmental Assessment and Plan of Operations for Disposal of Ton Container Ash and ESP Residue by Dry Land Dilution", dated 1 May 1974.

[44] AMXDC-O to RMA message, dated 29 May 1974, "Disposal of TC Ash and ESP Residue by Dry Land Dilution".

[45] State of Colorado, Department of Health Letter to RMA, dated 24 Aug 1973, "Disposal of Mustard Salts".

[46] SARRM-M Letter to PM, dated 5 Sep 1973, "Disposal of Salts".

[47] SARRM-M MFR, dated 22 Jan 1974, "Mustard Salt Disposal".

[48] RMA, MFR, dated 31 Jan 1974, titled: "ESP Damage, 25 Jan 1974".

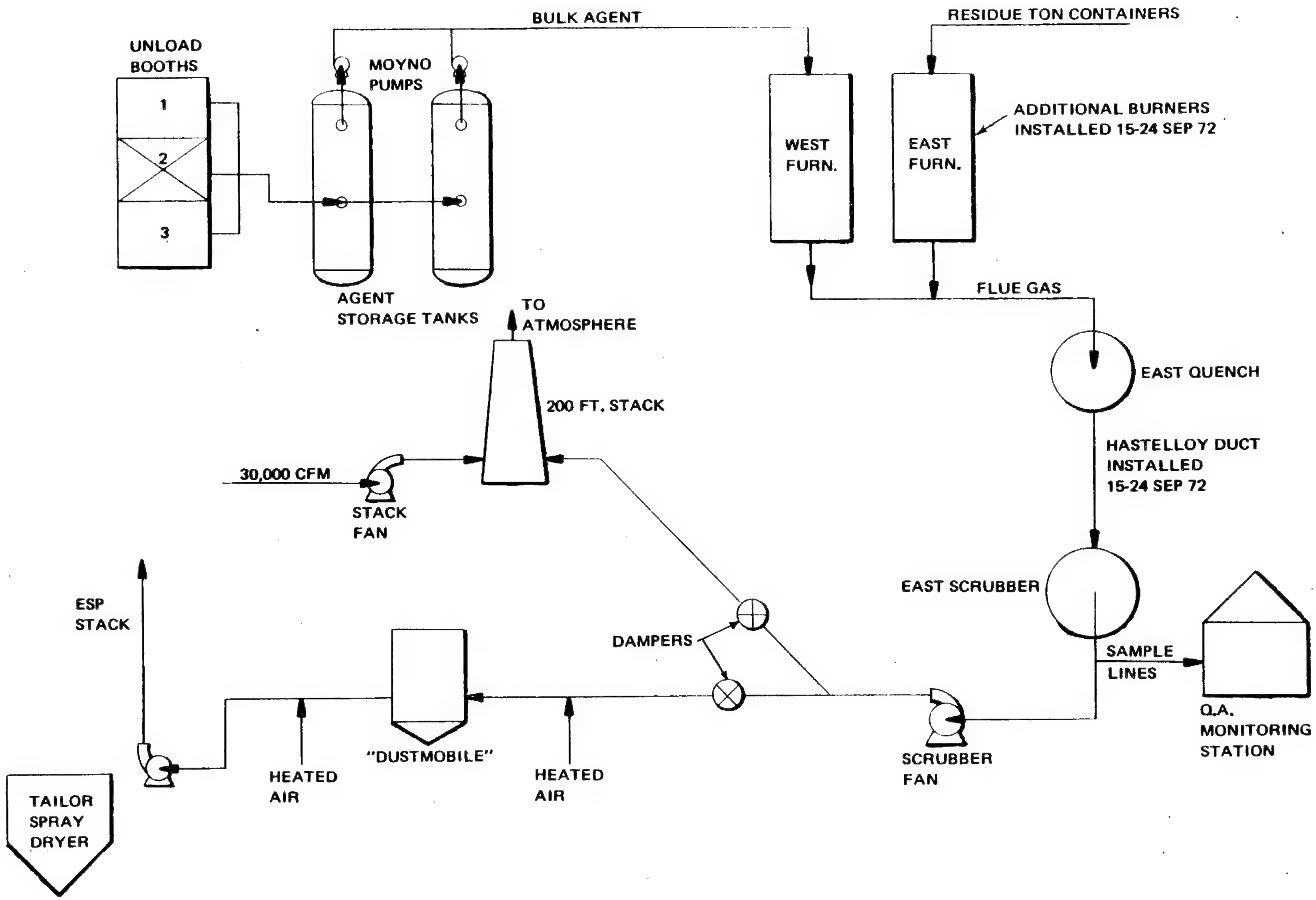


FIGURE 5–1 SYSTEM APPEARANCE AS OF 30 SEP., 1972

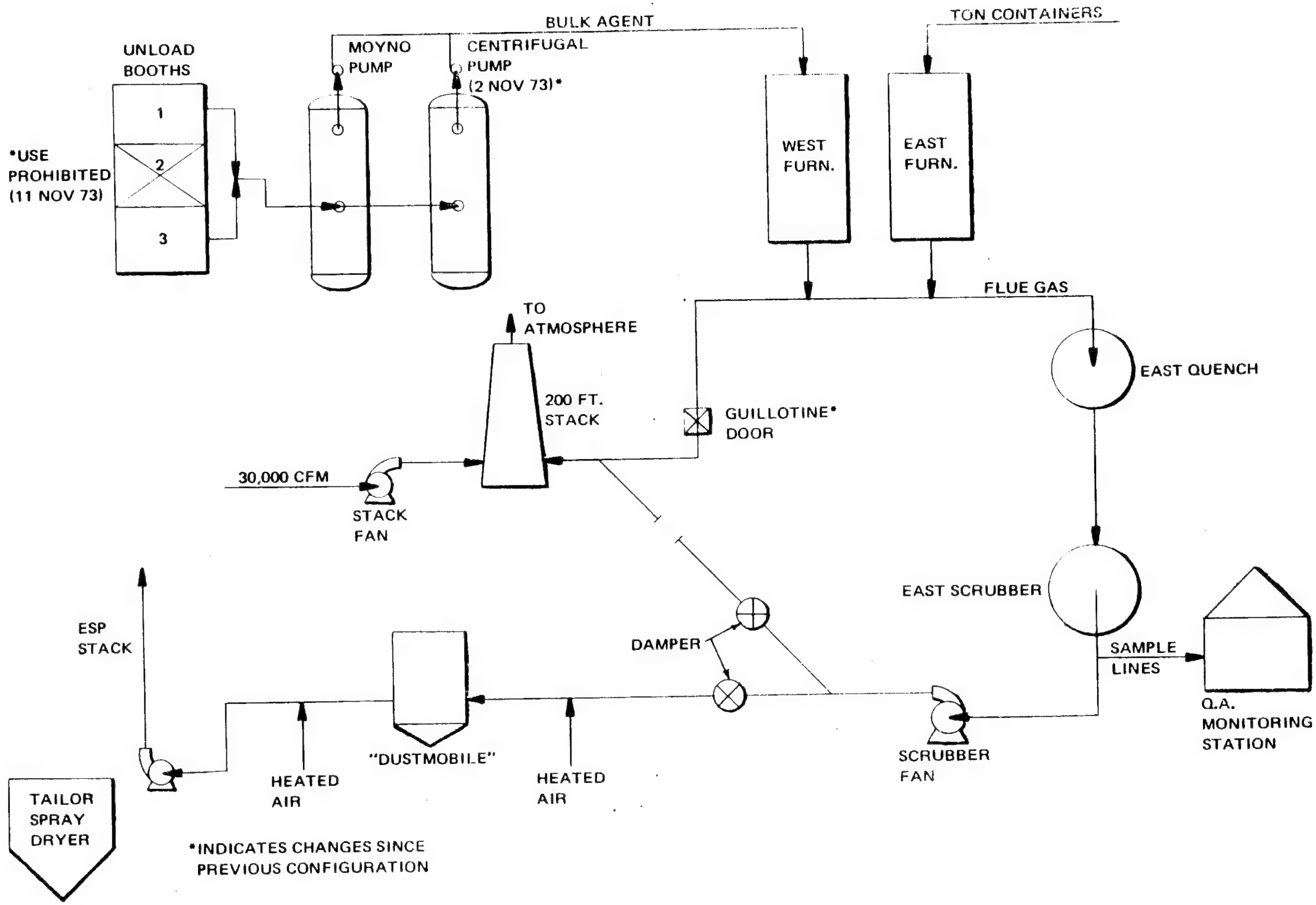


FIGURE 5–2 SYSTEM APPEARANCE AS OF 31 DEC., 1972

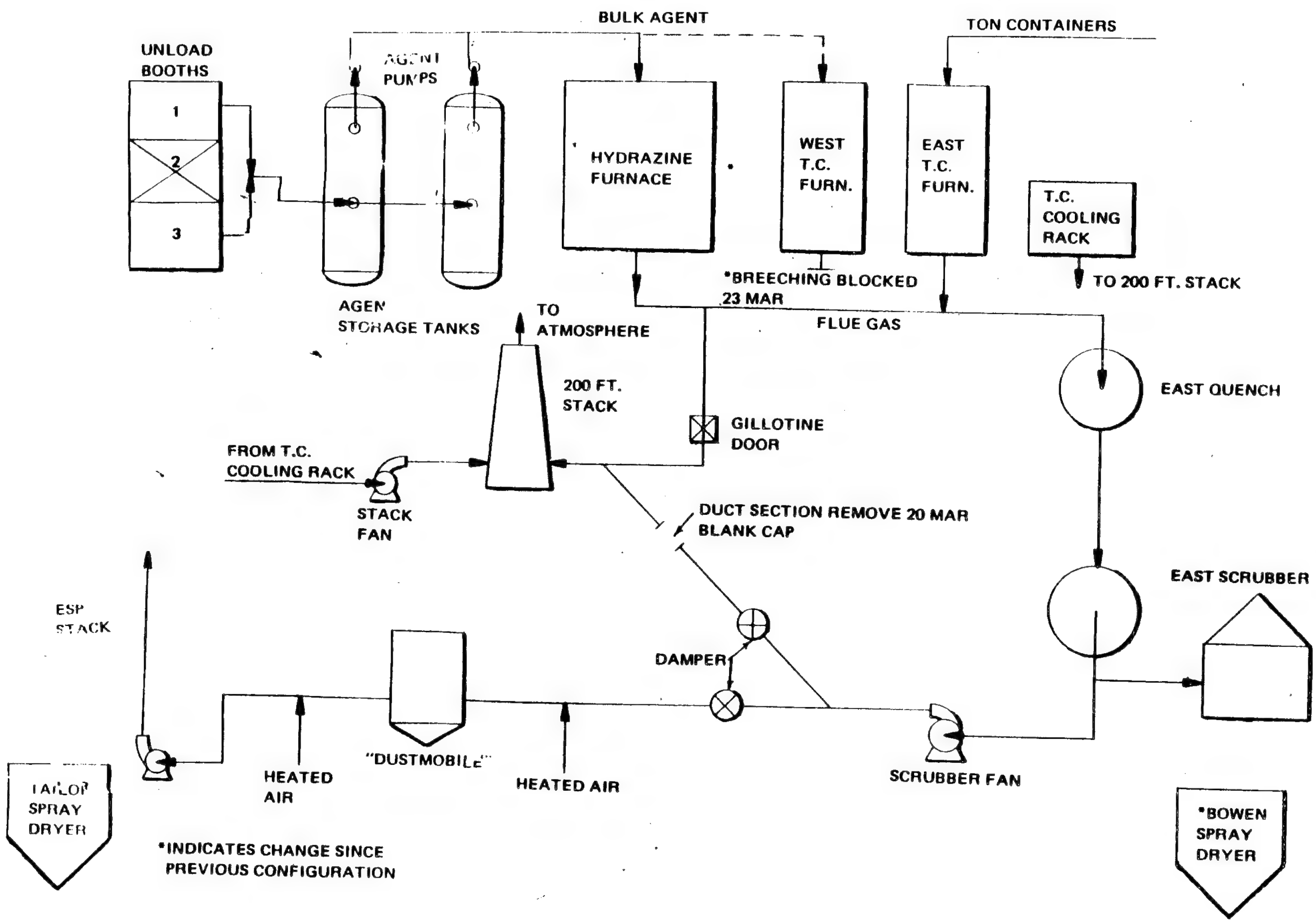


FIGURE 5–3. SYSTEM APPEARANCE AS OF 31 MAR., 1973

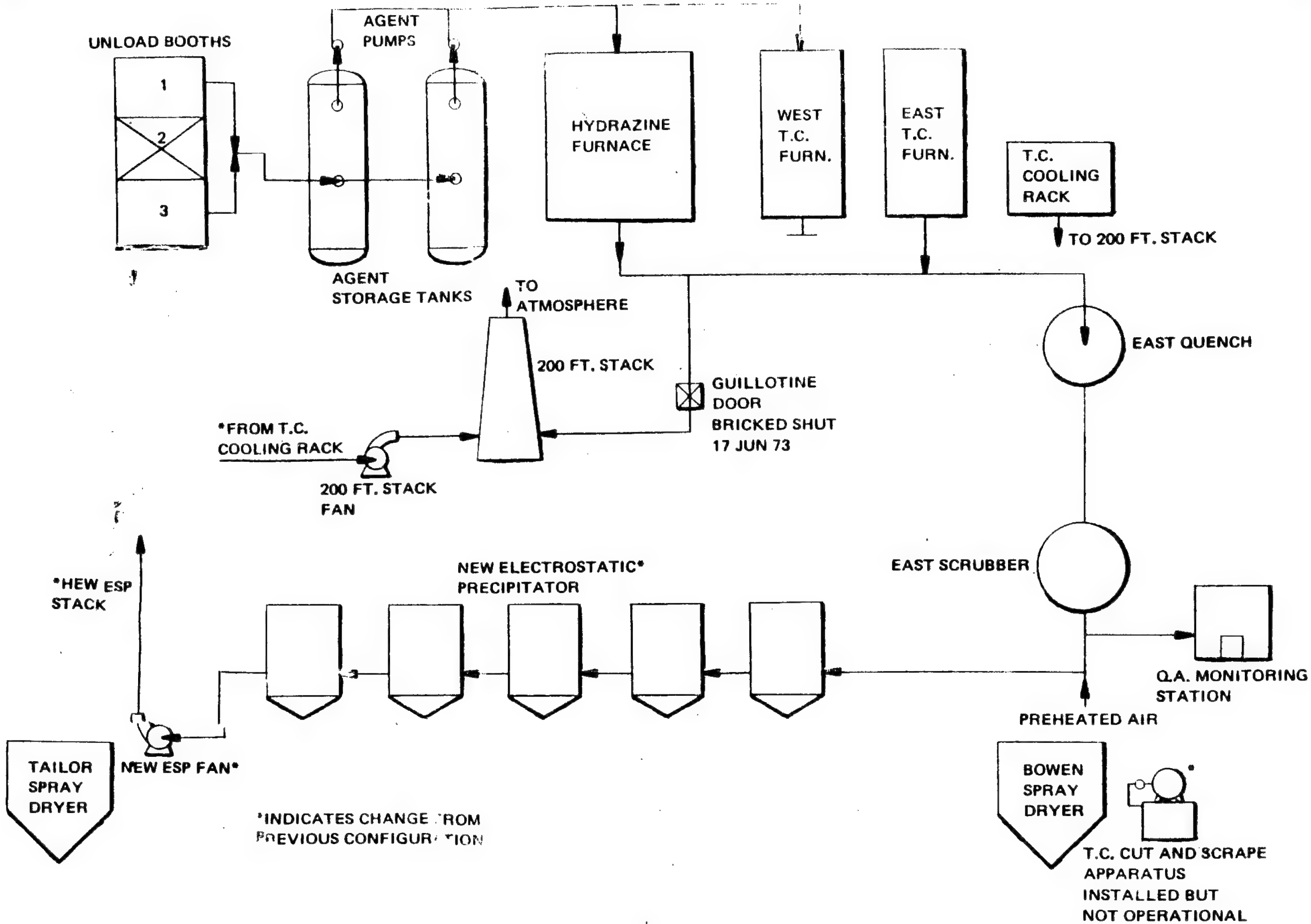


FIGURE 5-4. SYSTEM APPEARANCE AS OF MAY, 1973

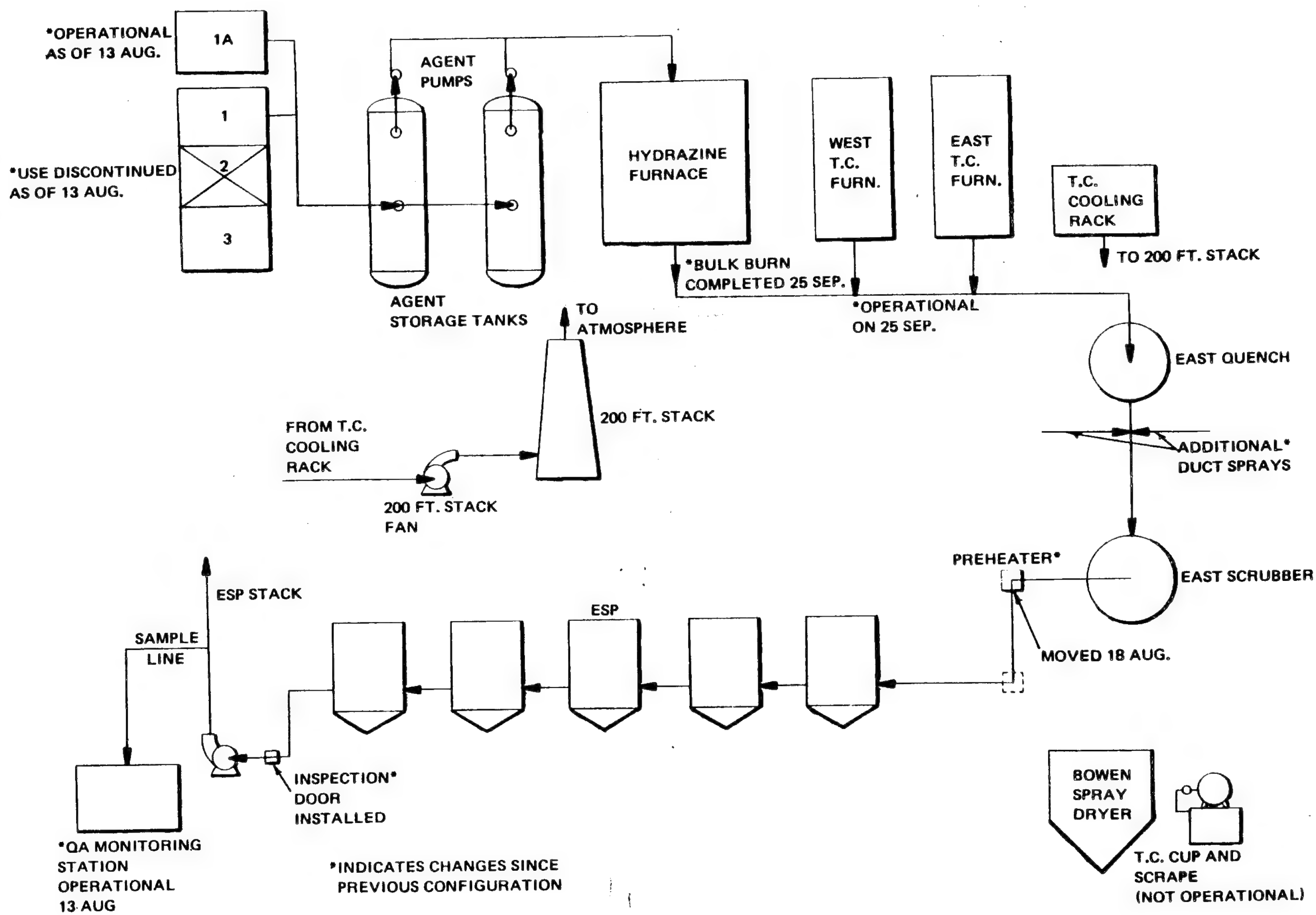


FIGURE 5–5 SYSTEM APPEARANCE AS OF 30 SEP., 1973

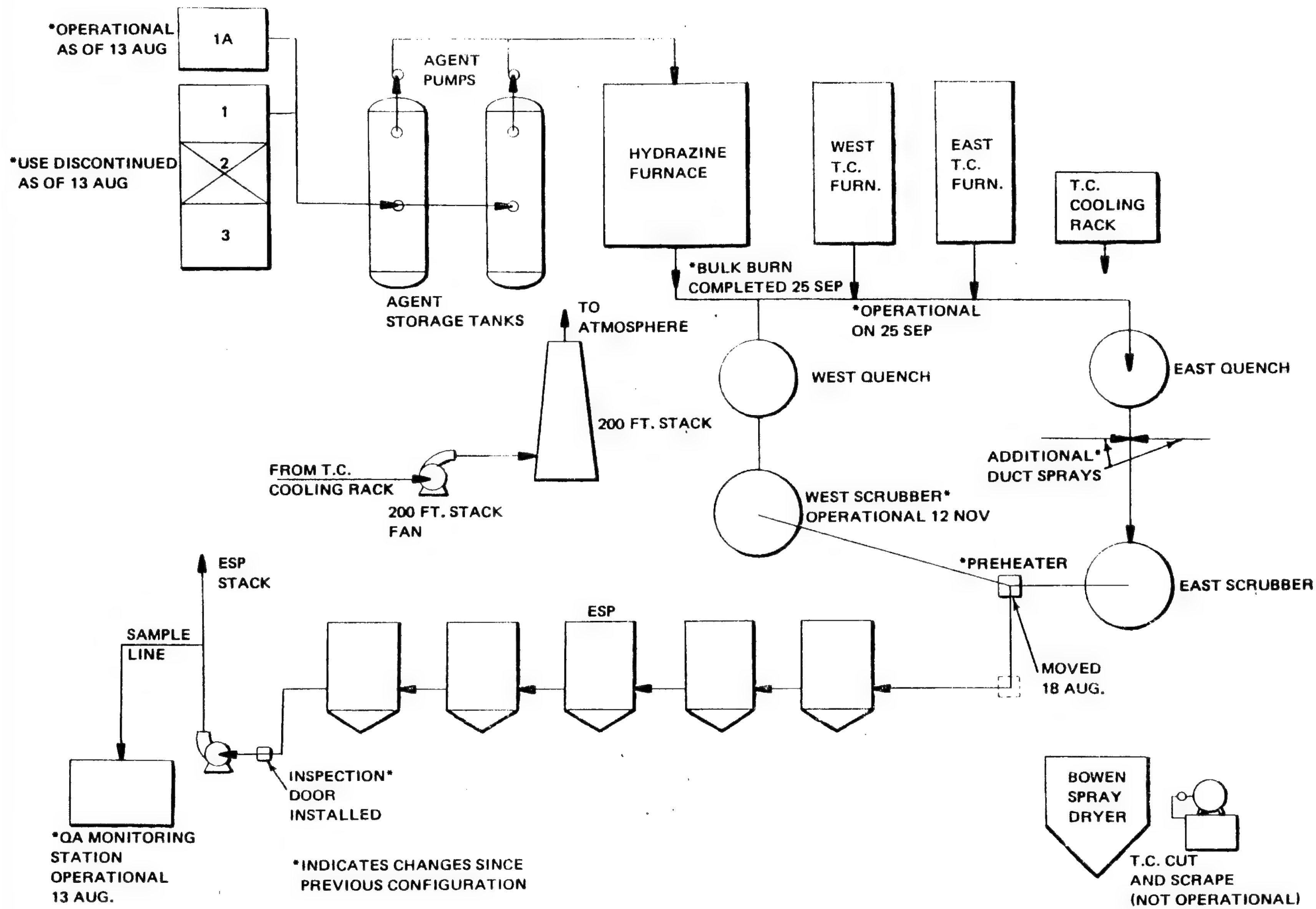


FIGURE 5–6 SYSTEM APPEARANCE AS OF 30 NOV., 1973

MONTH	TOTAL AVAIL. MIN.	TOTAL DOWNTIME		NORMAL WEEKLY				EQUIPMENT INSTALLATION		SYSTEM TESTING		MUSTARD FEED SYSTEM		EQUIPMENT FAILURE		ELECTRICAL		OTHER	
				Startup		Shutdown													
		Min.	%	Min.	%	Min.	%	Min.	%	Min.	%	Min.	%	Min.	%	Min.	%	Min.	%
Aug 72	12,510	1,830	14.6	215	11.7	240	13.1	0	0	0	0	185 Mustard Tank to Transfer Tank	10	1190 ESP Down	65	0	0	0	0
Sep 72	22,915	12,340	53.9	630	5.1	135	1.1	45 Install Spargers 7,200 Gross Burner Mods	0.4 58.3			500 Mustard FCV 1320 Nozzle Plugging 1125 Mustard Pump 245 Trans. H in Stg. Tanks 120 Repair H Line	4.1 10.7 4.1 2.0 1.0	480 ESP Down 135 Neg. Press. Loss 135 Scrubber Pump	3.9 1.1 1.1			270 Clean Furnace	2.1
Oct 72	30,240	5,980	19.8	1,130	18.9	185	3.1	130 Install Spargers	2.2	270 Check out Centrifugal Mustard Pump	1.9	1470 Nozzle Plugging 1085 Mustard Pumps 535 H Line Press. Rel.Valve	24.6 28.1 8.8	120 ESP Down 280 Scrubber Pump	2.0 4.7			275 Tracors Inoperative 180 Clean Furnace	4.6 3.0
Nov 72	30,240	14,185	46.9	510	3.6	85	0.6					680 Nozzle Plugging 740 Mustard Pumps	4.8 5.2	9530 Scrubber Fan Repair	67.2			325 Stack Alarm 2045 Frozen Pipes	2.3 14.4
Dec 72	27,360	4,560	16.7	455	10.0	275	6.0					25 H Flow Control Valve 300 Nozzle Plugging 370 Mustard Pumps 265 Trans. H in Stg. Tanks	0.6 6.6 8.1 5.8	75 ESP Down 105 Scrubber Pump 195 Plant Air Off	1.6 2.3 4.3			2495 Frozen Pipes	54.7
Jan 73	31,680	8,200	25.9	375	4.6	155	1.9					75 H Flow Control Valve 2200 Nozzle Plugging 155 Mustard Pumps	0.9 26.8 1.9	195 ESP Down 1035 Scrubber Pump 3560 Scrubber Fan Repair 50 Plant Air Off	2.4 12.6 43.4 0.6			170 Stack Alarm 100 Guillotine Door 130 H Leak E. Furnace	3.1 1.2 1.6
Feb 73	27,360	2,250	8.3	430	19.1	155	6.9	165 Install Spargers	7.3			135 Nozzle Plugging 140 Change H Valve	6.0 6.2	645 Scrubber Fan Repair 25 T.C. Punch	28.7 1.1			70 Stack Alarm 485 Frozen Caustic Car	3.1 21.6

TABLE 5–1. SYSTEM DOWNTIME AND CAUSES (Sheet 1 of 3)

MONTH	TOTAL AVAIL. MIN.	TOTAL DOWNTIME		NORMAL WEEKLY				EQUIPMENT INSTALLATION		SYSTEM TESTING		MUSTARD FEED SYSTEM		EQUIPMENT FAILURE		ELECTRICAL		OTHER	
				Startup		Shutdown													
		Min.	%	Min.	%	Min.	%	Min.	%	Min.	%	Min.	%	Min.	%	Min.	%	Min.	%
Mar 73	31,680	3,469	11.0	583	16.8	135	3.9			1928 Hydrazine Furnace	55.6	240 Nozzle Plugging 353 Mustard Pumps	6.9 10.2	195 Scrubber Diesel Pump	5.6	35 Non Specific	1.0		
Apr 73	30,240	6,318	20.9	575	9.1	125	2.0					410 Mustard Pumps	6.5	495 ESP Down 63 Hydrazine Furnace Flame Out 25 Scrubber Pump 4568 Scrubber Fan Repair	7.8 1.0 0.4 72.3	63 Non Specific	1.0	57 Guillotine Door	0.9
May 73	31,680	7,870	28.4	415	5.3	140	1.8	535 Cune Hydra Furn Repaired Ceramic 3575 Tie-in new ESP	6.8 45.4	605 New ESP Air Flow Testing	7.7			2245 Scrubber Packing Support Repair	28.5	135 Power Outage	1.7	220 Guillotine Door	2.8
Jun 73	30,240	2,960	9.8	590	19.9	755	25.5							150 Scrubber Pump 35 Quench Tower Salting Up 110 Salt Compactor 1255 Salt Conveyor Belt	5.0 1.2 3.7 42.5			65 Stack Alarm	2.2
Jul 73	30,240	2,890	9.6	385	13.3	350	12.1					480 H Flow Control Valve 600 Mustard Pumps	16.6 20.8	25 Scrubber Pump	0.4			965 Thaw Room Spill 85 Brine Storage Full	33.4 2.9
Aug 73	33,120	2,955	8.9	355	12.0	210	7.1			185 T.C. Burn Test	6.3	815 Hydrazine Furnace Feed Problems 496 H Flow Control Valve 480 Mustard Pump	27.6 16.8 16.2	10 Scrubber Pump	0.3	225 Power Outage 180 Bldg. 540 Substa	7.6 6.1		
Sep 73	22,915	1,250	5.6	195	15.6	220	8.0					160 Hydrazine Furnace Feed Problems	12.8	995 Scrubber Level Switch Failure	63.6				

TABLE 5–1. SYSTEM DOWNTIME AND CAUSES (Sheet 2 of 3)

MONTH	TOTAL AVAIL. MIN.	TOTAL DOWNTIME		NORMAL WEEKLY				EQUIPMENT INSTALLATION		SYSTEM TESTING		MUSTARD FEED SYSTEM		EQUIPMENT FAILURE		ELECTRICAL		OTHER	
				Startup		Shutdown													
		Min.	%	Min.	%	Min.	%	Min.	%	Min.	%	Min.	%	Min.	%	Min.	%	Min.	%
Oct 73	30,240	2,775	9.2	200	7.2	160	5.8	1920 Tie-in new Scrubber	69.2					495 Ton Container Changing Cart	17.8				
Nov 73	30,240	2,360	7.8	445	18.9	420	17.8			805 West Scrubber Test	34.1			690 ESP Fan Coupling Failure	29.2				
Dec 73	27,360	1,290	4.7	505	39.2	275	21.3			145 CAMDS Shell Test 160 T.C. Burn Test	11.3 12.4			100 T.C. Hoist Down 105 T.C. Changing Cart	7.7 8.1				
Jan 74	33,120	2,870	8.7	615	21.4	300	10.5			770 CAMDS Shell Test	26.8			1185 ESP Overpressure Damage	41.3				
Feb 74	18,720	4,599	24.6	165	3.6	150	3.3			4284 CAMDS Testing	93.2								

TABLE 5–1. SYSTEM DOWNTIME AND CAUSES (Sheet 3 of 3)

AGENT WEIGHT DRAINED	1971	1972											1973								
	Dec	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	0	2	3	6	10	10	10	10	12	20	23	25	31	31	36	41	46	49	60	65	74
1 - 100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
101 - 200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
201 - 300	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
301 - 400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	3
401 - 500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	6
501 - 600	0	0	0	0	0	0	0	1	1	2	2	2	2	2	2	3	3	3	5	7	10
601 - 700	0	0	0	0	0	0	0	0	0	4	8	8	8	8	8	8	8	15	16	18	25
701 - 800	0	0	0	1	1	1	1	2	4	6	7	10	13	13	15	15	16	22	27	29	32
801 - 900	0	1	1	2	2	2	2	3	9	17	19	22	24	24	24	28	34	44	47	57	58
901 - 1000	0	1	2	4	4	8	9	13	18	24	25	28	31	31	39	45	54	74	80	90	101
1001 - 1100	1	2	2	2	2	9	9	13	17	26	30	39	46	46	55	77	96	144	177	195	210
1101 - 1200	0	0	0	3	3	11	11	17	23	37	42	60	65	65	76	104	133	166	198	224	241
1201 - 1300	5	8	8	10	10	21	21	30	32	43	50	67	70	70	80	101	134	183	201	218	244
1301 - 1400	0	1	1	2	2	19	20	23	27	29	37	49	53	53	65	86	114	169	214	228	242
1401 - 1500	0	4	4	9	9	23	24	33	39	48	52	63	69	69	79	109	138	167	213	233	268
1501 - 1600	3	8	9	17	17	28	28	40	50	55	61	75	84	84	99	135	173	231	302	349	425
1601 - 1700	1	18	18	28	28	42	42	46	58	67	76	83	90	90	102	158	211	273	356	443	499
1701 - 1800	0	10	11	19	19	29	29	30	33	35	37	37	38	38	40	45	51	59	64	99	110
1801 - 1900	1	2	2	2	2	2	2	2	2	3	3	3	4	4	4	5	6	7	8	9	9
1901 - 2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001 - 2100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
For Residue Weight Subtract Agent Drained from 1800 Lbs.														No H T.C.'s drained during February.							

TABLE 5–2 T.C.'S DRAINED PER WEIGHT GROUP

SECTION 6

PRODUCTION CONTROL PROCEDURES AND SCHEDULE PERFORMANCE

6.1 GENERAL, PRODUCTION CONTROL

The Production Control system of data collection and processing was the result of a continuing effort at process improvement. Although most of the Inventory Control forms and data collection sheets had been long established due to the Tailor system shakedown operation, a concerted effort to use the information thus acquired for other than inventory control and progress reporting was not made until additional engineering assistance was provided in January to February 1973. At this time process engineering was begun to use the data to improve the demilitarization operation; this effort was to continue throughout the program. Additionally, a thorough revision of all plant data collection forms was made during May 1973.

6.2 OBJECTIVES OF THE PRODUCTION CONTROL SYSTEM

The objectives of the Production Control system were fourfold:

A. To provide data sufficient to track the agent inventory in bulk and as container units through the demilitarization process.

B. To facilitate process improvement by supplying data to the Process Engineering Section on the individual operations within the incineration process.

C. To allow the Mustard Demil staff to track the progress of the overall demil operation versus the established schedules and to report to the Commander, RMA, and the Program Manager for Demilitarization on the status of the demil effort.

D. To order and deliver sufficient materials and spare parts to support the demilitarization operation.

6.3 PRODUCTION CONTROL DATA SHEETS, PRODUCTION REPORTS, LOGBOOKS

The system of Data Sheets and Production Reports developed during the Mustard Demil Program comprised two distinct types of material: Plant-generated and Mustard Demil/RMA command-generated.

6.3.1 PLANT GENERATED INFORMATION (Table 6–1)

A. B-537 Logbook (Item 1)

This logbook contained operational entries of any information which the Building 537 foreman wished to record. Required data recorded on a routine basis consisted of shift entries regarding the charcoal bed filter pressure drops,

switching of the instrument air dryers, vacuum pump seal water changeout and pH, area bubbler results, record of incoming ton containers, mustard pump pressures, mustard tank levels before and after agent dumping and transfer, changeout of unload booth gloves, and changeout of unload booth rubber hoses. This information was extracted from the logs daily for incorporation into the Weekly Progress Report (Item 9, Table 6–2). The logbook also acted as a written record of operations for documentation purposes should an accident occur in the operational area so documented.

B. Shift Engineers Logbook (Item 2)

This logbook contained any operational entries which the Shift Engineers desired to record. The book also served as a vehicle for the plant manager or process engineer to pass on and/or rescind *in writing* changes to operational conditions, whether equipment- or safety-related. An additional useful result of the book's use was to maintain closer coordination among the three shift engineers and to pass on for consideration suggestions for safety or operations modifications. Data from this log was extracted for inclusion in the Weekly Progress Report.

C. Mustard Ton Container (T.C.) Unloading Form (Items 3 and 4)

This form was used for inventory control purposes. In addition, considerable work was done using the agent drain data to predict agent draining characteristics of containers yet to be drained. The data from this form was included on the inventory control form for T.C. unloading (Item 1, Table 6–2) for permanent record. The earlier form was superseded by revision 1 which combined two forms into one. The earlier mustard tank outage form (Item 6) was withdrawn from use in favor of the subject form. Tank outage readings were taken every hour in order to compute the number of gallons of agent burned per hour. The difference (in inches) in tank levels observed over an hour period was checked against a chart giving the volume of the storage tank as a function of the level observed on a sight glass on the end of the horizontal tank. Since no practicable flowmeter had been found during the program which would perform accurately (if at all) the measurement of agent flow by tank outage remained as a less efficient but workable method. Further study into flowmeters for corrosive and particulate-laden fluids may resolve this particular problem. The data computed from this portion of the unloading form was used, along with the rest of the information on the form, to make up the shift engineer's Daily Summary Report (Item 16).

D. Quality Assurance Form - H & HD Container Data Card (Item 5)

This form was used by the Quality Assurance Inspection and Verification Inspectors to track ton container lot/serial number data, weight data and blue band tube test results. A card was filled out for each container during the transfer operation and again during the residue incineration operation. An additional card was filled in if the container was reburned due to residual

contamination after the initial burn (positive blue band test result). The cards were sent weekly to Data Processing where the data was transcribed onto punched cards and run on the computer. A weekly summary report (Item 18, Table 6–2) by agent type and container serial number was presented to Quality Assurance on a weekly basis.

E. Ton Container Decontamination Form (Item 8)

This form was filled out by operating personnel on a daily basis. Information recorded was weight and time data for each ton container incinerated. The containers were identified by serial number, type of agent, and furnace used (after 26 September 1973). Two residue weights were recorded: the "as marked" weight marked on the ton container during the drain process and the "actual" weight derived from a direct measurement before and after incineration. The "as marked" residue weight went into the Production Control Daily Progress report for inventory control and production vs. schedule use. The "actual" residue weight went into the Daily T.C. Summary. Report filled out by the shift engineer (after 26 September 1973). Since the variance between the two weights could be significant, the "actual" weight was used for process control and as a data base for improving the T.C. residue burning.

F. Ton Container Furnace and Hydrazine Furnace Logbook - B538 (Item 9)

This logbook was kept by the operating personnel to record operational data. Time and serial number entries were made in the log on each container incinerated. Hydrazine furnace data such as downtime and mustard on/off times were also recorded. Information extracted from this logbook was incorporated in the Weekly Status Report (Item 9, Table 6–2).

G. Ton Container Cut and Scrape Logbook - B540 (Item 10)

Data entries in this logbook were made by reporting personnel. Information recorded was ton container serial number and sequential number cut per shift, ash drum lot (changed daily), drum number (sequential for day) and positive/negative results or agent analysis of the scraped ash.

H. Spray Dryer, East Scrubber, West Scrubber and Electrostatic Precipitator Logbooks (Items 11 through 14)

These logbooks were used primarily for recording operational data out of the realm of the usual collected data. Unusual occurrences, such as equipment failures, were also recorded. The number and drum weight of residue removed from the Electrostatic Precipitator each week was recorded in the ESP log.

I. QA Monitoring Station Logbook (Item 15)

Bubbler results, SO_2 emission levels, tracor status and calibration were recorded in the monitoring station logbook.

J. Daily Summary Report by Shift Engineer (Item 16)

Two types of forms were used as a Daily Summary Report by the Shift Engineers. The first form used from the start of the program until December 1973 summarized the daily production to include: T.C.'s dumped, weight of agent dumped, T.C.'s burned by shift and total, salt hauled, salt dumps produced, number of T.C.'s required for thaw room, downtime minutes and causes, caustic car status, and T.C.'s cut. After December 1973, the agent drain and bulk agent burn data was dropped from the form and a section added for T.C. cutting and ash barrelling. This form remained in the plant after being filled in.

K. Daily T.C. Decontamination Summary (Item 17)

This form was completed by the Shift Engineer each morning and sent to the Process Engineering Section. Poundage data was recorded on "actual" weight to be used in computing totals and averages for Production charts (see Table 6–2).

L. Hydrazine Furnace, East Quench, East Scrubber, West Scrubber, Bowen Spray Dryer, and Electrostatic Precipitator Data Sheets (Items 18 through 22)

These data sheets were completed once each day. Readings were taken every hour by operating personnel. Data recorded was process instrument data such as pressures, temperatures, flow rates, liquid levels, specific quantities, amperages, solution alkalinity, etc. The completed sheets were grouped by day and stored in the plant for reference.

M. Request for Issue on Turn In (Item 23)

This form was completed by the Quality Assurance Inspection and Verification Inspector on duty. Completion of this form certified that the containers had been decontaminated by burning and were free from agent. The form contained the serial numbers of cut ton containers and was completed prior to their release from the plant but after the ash from the containers had been analyzed for agent content and negative results received from the Quality Assurance Laboratory. The original of this form went to RMA Property Disposal with QA office and Mustard Demil office receiving file copies.

N. Hazardous Work Permit (Item 24)

This form was required to be completed by the foreman or engineer on duty prior to maintenance on decontamination operations involving agent. The form must have been signed by a Safety Office representative prior to start of the operation. A copy of the completed form was retained in the plant with another copy going to the Safety Office. The foreman of the crew performing the operation received the original.

O. Ton Container Furnace Time/Temperature Charts (Item 25)

Continuous 24-hour trace of ton container furnace and flue temperatures was maintained. Ton container data was entered for each container into the furnace. Observation of time/temperature trace allowed process engineering to check on compliance with established burning procedures by measuring temperature peak height, values of inflection points, etc. Charts were kept in the plant as part of each day's data sheet package.

6.3.2 MUSTARD DEMILITARIZATION PRODUCTION CONTROL FORMS, REPORTS AND PROGRESS CHARTS (Table 6–2)

A. Daily Production Report, T.C.'s Emptied (Item 1, Table 6–2)

This form was maintained in the Production Control section on a daily basis. Ton container drain data as shown on the example was recorded for each container, one sheet being used for each day's operation. The sheet served a dual purpose in that as containers were recorded on the Ton Container Decontamination Sheet (Item 2) the containers on the T.C.'s emptied sheet were crossed off in an attempt to maintain a continuous track on containers throughout the incineration process. Completed forms were collected and filed in the Mustard Demil filing system.

B. Ton Container Decontamination (Item 2)

This form was similar in use to the T.C. emptied daily progress report above.

C. Manufacturing Division Progress Report (Item 3)

This form was a carryover from the Production Division Manufacturing report; its use was continued because it was a convenient form and there were large stocks of blank forms remaining. Data reported on this form was drawn from the reports and information sheets generated in the Mustard Plant. The primary input was the early morning telephonic summary report from the Shift Engineer to the Production Controller. This report form incorporated a variety of data including agent drained data, agent burned data, ton container incineration data, and downtime totals and reasons. The contents remained flexible and varied with the progress of the program through its various phases. Information from this report was used by the Shift Engineer to post the Arsenal Commander's data book. This data book was maintained on a daily basis for the use and information of the Commander.

D. Overall Progress Chart (Item 4)

1. Chart Type 1

This chart was prepared by the Production Controller each day. The scheduled rate line was computed using the minimum required agent burn

(nozzle plus residue) based on a 100 percent operating day (no downtime). This rate changed as the scheduled requirement changed. The computation of the actual disposal rate was based on data from the daily progress report (Item 3). The agent burned through the nozzle (in gallons) was added to the "as marked" residue burned (converted to gallons using a density of 10.0 LBS/GAL) and divided through by 1440 minutes per operating day. After April 1973, the process engineering section began using this chart to record a breakdown of the agent destroyed, numbers of T.C.'s incinerated, downtime minutes, and downtime causes. This chart was posted in the Mustard Demil office and was used to track production and observe upward or downward production trends. Use of this chart was discontinued at the completion of bulk agent incineration.

2. Chart Type 2

This chart was also prepared by the Production Controller each day. Bulk agent destroyed was expressed in terms of pounds rather than GPM. The residue destroyed was expressed in gallons destroyed, since it was normally averaging 2000 pounds per day and compression of the vertical axis to include up to 6000 pounds would also compress the bulk burn portion of the chart and decrease its useful value to the process engineering section. This chart was used during Phases I and II when bulk agent incineration was of higher priority than residue incineration. Copies of this chart were posted in the Plant Break trailer in order to keep the operators apprised of the operation's progress and to foster a competitive spirit among the shift crews. The sections of each bar on the chart were color-coded by shift; the bottom section was green for graveyard shift, the second section red for days, the third blue for swing, and the top section brown for total T.C. residue (not broken out by shift). The numbers in each section also had significance. The use of the numbers 1, 2 or 3 at the bottom of each section indicated the shift engineers in charge of the shift. The three or four digit numbers indicated the exact amount of agent destroyed in each shift expressed in pounds. This chart was updated and posted daily. Use of this chart was discontinued on 25 September 1973, due to the completion of Phase II.

E. T.C. Residue Progress Chart (Item 5)

This chart was a process engineering tool composed of a plot of the total number of pounds of ton container residue burned each day vs. the calendar date. This time trace was started on 1 May 1973, and continued until approximately 30 December 1973, spanning the latter part of Phase I, all of Phase II and the first three months of Phase III. The primary use of the chart was to observe trends in the ton container residue destruction as a function of time in order to control better the effectiveness of the T.C. decontamination operation. Use of the chart was discontinued at the end of December 1973, due to the concentration at that point on completion of schedule ahead of the target date based on numbers of containers destroyed rather than on residue

burned. It should be noted that the chart actually contains two plots since the container residue totals used were expressed as "actual" and "as marked" as was discussed in Paragraph 6.3.1 (C). Since the "as marked" residue was the inventory agent left over after draining, this residue weight was used to set schedules and measure schedule completions. The "actual" residue weight was used for engineering purposes since it was a direct measurement indicator of the residue content of a container. It was a disadvantage that this data could only be collected after a container had been burned, therefore, it became necessary to make extensive use of projections of residue contained in unburned containers based on a compiled distribution of residue weights of containers already burned. Use of this technique was quite reliable and the projections were periodically updated for use in calculating estimates of Phase III termination. It eventually became possible, after considerable study, to predict a container's residue weight prior to incineration with accuracy sufficient to set approximate burn times and peak temperature. This chart was displayed in the Mustard Demil Office in the belief that it would not only provide updated information for casual visitors but also elicit comments and observations from the office staff on implications of the charted data which may or may not have been seen by the process engineering personnel.

F. Average Residue Burned per Ton Container (Item 6)

This chart was a double plot of the average weight of residue burned per container and the number of H mustard containers burned per calendar day. The use of this chart was confined to process control. The data plotted was computed by dividing the actual residue burned by the total number of ton containers incinerated in a 24-hour period. As of 25 September 1973, the data for the west ton container furnace was plotted in addition to the already charted east furnace data. The plot of ton containers burned per day was confined to H containers for simplicity. Use of both graphs gave the process engineer the information necessary to make process control decisions.

G. Ton Container Residue Burned Cumulative (Item 7)

This chart was similar in function to the preceding two in that it was a day by day review of Phase II and part of Phase III from the ton container incineration aspect. The chart was posted daily from the Production Control daily report with both "as marked" and "actual" cumulative residue weights. Data was first plotted on 1 June 1973, at the beginning of Phase II and discontinued on 5 October when the Phase III schedule emphasis shifted from residue poundage to numbers of ton containers incinerated per day. It should be noted that the cumulative totals plotted did not reflect the total residue burned since the beginning of the program but only the total cumulative residue burned during Phase II.

H. Ton Containers Cumulative Cut and Scraped (Item 8)

This chart was begun on 30 August 1973, continued until the end of the program, and had its inception at approximately the point when it was recognized that the most valuable schedule to follow during Phase III would be numbers of containers rather than residue poundage. The data plotted consisted (until mid-September 1973) of the cumulative total of ton containers incinerated from the beginning of the program, to include Tailor system testing. This actual rate was posted daily and contrasted with the schedules set internally by the Mustard Demil Office. As Phase III approached its termination, the chart was very useful in estimating completion date by extrapolation. The ton container cut and scrape operation's progress was also documented on this plot resulting in a great deal of ease in visualizing the progression of these simultaneous operations which had to be as nearly co-terminal as possible.

I. Weekly Status Report (Item 9)

The weekly status report was compiled by the Production Control section and sent by Disposition Form to the Chief Engineer of RMA. The report was composed of a compilation of extracts from the operational logbooks taken daily. Data from the Production Control Daily Report also went into its preparation. The logbook extracts consisted of detailed information, by operating day, on process conditions, and downtime. Normal checks and routine performance of maintenance were also noted. The weekend maintenance work was also documented. The report covered a calendar week as opposed to the Thursday through Wednesday report week required by the Program Manager's Office. Additionally, at the end of each month, this report included a summary of major downtimes related to each problem area.

J. Weekly Progress Report (Message) (Item 10)

The RMA Chief Engineer submitted the Thursday through Wednesday Progress Report by message to the Program Manager each Thursday. This report contained the production summaries for the report week as well as cumulative totals for the program. Additionally, a capsule write-up of major downtimes and operational problems was included. This report was compiled from the daily reports provided to the Chief Engineer.

K. Monthly Sodium Hydroxide Usage Report (Item 11)

This report was provided to the RMA Supply Division through the RMA Chief Engineer at the end of every calendar month. The information contained in the report was use of caustic expressed in tons of 50 percent solution. The tonnage was derived from a computation involving the month ending inventory of all 50 percent caustic on hand, the receipts of 50 percent caustic during the month, and the gallonage of 18 percent in the ready caustic storage tank (calculated back to 50 percent and converted to tons). The primary purpose of this report was to aid the Supply Division of Logistical Services in contrasting caustic usage against Arsenal-wide inventories and expected receipts.

L. Program Progress Chart (Item 12)

This chart was an overall view of the status of the actual mustard destruction vs. the various schedules applied by the Program Manager's Office. The data plotted vs. calendar consisted of the total cumulative agent destroyed (bulk plus "as marked" T.C. residue) expressed in gallons for the report week, based on the amounts reported by the Chief Engineer in his Weekly Progress Report Message (Item 10). The chart proved very useful in determining the status of each phase of the program as it progressed and in estimating phase completion by graphical extrapolation. This plot was made up in engineering drawing sheet format and posted in the Mustard Demil Office for informational purposes. The updated chart was also used for preparation of viewgraphs for briefings as required.

M. Monthly Feeder Report (Item 13)

This report was a monthly summary of normal production data and was furnished by Disposition Form to the Work Measurement Office of the RMA Comptroller by the Mustard Demil Production Controller.

N. RMA Demilitarization Report (Item 14)

The RMA Demilitarization Report was prepared on a monthly basis by the RMA Chief Engineer and contained a narrative summary of the month's production as well as cumulative totals as of the end of the month. A tabulation of downtime information was included. Additionally, there was a section dealing with the milestones accomplished during the month as well as a projection of the succeeding month's milestones.

O. Commander's Quarterly Review and Analysis (Item 15)

The Commander of RMA held a Program Review and Analysis briefing each quarter of the fiscal year. The contribution to this briefing of the Mustard Demil office was in the form of a formal narrative briefing given from a prepared text with viewgraphs and slides. The information presented was composed of the status of the program during the quarter being briefed, analyses of performance and downtime, milestones achieved, milestones projected, and manpower utilization data. All texts were maintained by the RMA Comptroller's Office for permanent filing.

P. Earned Hour Report (Item 16)

This report was provided to Mustard Demil by the Work Measurement Office of the RMA Comptroller and contained the calculated efficiency of each of the Demil Program's operations vs. the established work measurement standards. This report served as a useful tool by aiding the Program Director to assess his operation's performance, take corrective action for low efficiency functions, and monitor the charging of labor hours against an individual step in the demil operation.

Q. Manhour and Cost Reports (Item 17)

Various reports provided to the Production Control Office of Mustard Demil by the RMA Comptroller's Office containing manhour utilization, actual cost against budgets, leave usage, etc.

R. ADPE Report No. 9005, H-HD Container and Burn Data (Item 18)

This report was a computer printout summary of the ton container data contained on the Quality Assurance data cards (Item 5, Table 6–1) submitted to Data Processing each week. The entire summary was updated each week with the containers arranged by type of agent and by serial number. Additional data consisted of drain, burn weight, and date information as well as lot number and fill date information. This report served as the source document for most of the container weight analyses done utilizing fill dates and lot numbers.

S. Request for and Results of Analysis (Item 19)

Quality Assurance laboratory provided this report daily to the Director of Mustard Demil. It consisted of an hour-by-hour listing of ESP stack mustard bubbler agent contents and pH/specific gravity/mustard content of scrubber brine samples.

T. Bi-Weekly Plant Roster (Item 20)

The Mustard Operations Division provided a biweekly listing of all personnel on each shift. Each 2-week period, personnel changed shifts with the order being from day to swing to graveyard. This notice served to alert personnel to their assignments, complied with Union agreements and provided a continuing ready roster of personnel on each shift.

U. Punch List (Item 21)

The Punch List was prepared weekly by the Director of the Mustard Operations Division to define the priority of maintenance tasks to be undertaken on the weekend because of interference with operations. This document served as a basis for determining the priority of efforts and skills of the work force required, and provided a basis for material planning for weekend work.

V. Preventive Manual Checkoff Sheets (Item 22)

The preventive maintenance manual provides a detailed description of each piece of equipment in the plant with a description of its preventive maintenance requirements. A typical piece of equipment might require several weekly tasks, a monthly task, and a yearly task. The maintenance manual balanced all these tasks so that each week about the same level of effort was required for preventive maintenance, although the tasks were widely varied.

Each week, a Xerox copy of all sheets defining required task for that particular week were furnished to the Maintenance Foreman. He in turn assigned the work, and each maintenance man signed off those tasks when completed. Once completed, the sheets were returned to the maintenance scheduling office (for each week) to be retained as verification of the completion of the preventive maintenance tasks for that period.

6.4 PRODUCTION CONTROL SUMMARY AND RECOMMENDATIONS

The Production Control system eventually evolved for use during the Mustard Demilitarization program as adequate to complete the program in a safe manner and well ahead of schedule. There were, however, several shortcomings, all of which were due primarily to a continual lack of sufficient full-time, permanent production control and process engineering personnel. The program was at a disadvantage throughout its course in that new studies and testing programs were continually pressing to be accomplished while the personnel required to tabulate, store, and routinely analyze the data so collected were not available. TDY personnel, although immensely helpful, could not fulfill this requirement of permanency. If routine data collection was hampered by this inadequacy, then it follows that the time and effort required to reexamine, change, and implement a data collection and storage system was not available.

Recommendations for future use in designing a chemical demilitarization facility are:

A. Establishment of an expanded production control office with a capability in the Industrial Engineering, Data Analysis, and Internal Quality Control fields; and

B. An automatic Data Processing capability which would aid in data tabulation and storage as well as in tracking container inventory by serial number (with a mistake rejection subroutine).

6.5 SCHEDULE ESTABLISHMENTS, MODIFICATIONS AND ANALYSES

6.5.1 ORIGINAL PROGRAM SCHEDULE

The original program schedule assumed that the installation of the bulk agent incinerator and the modification of the ton container burning system would be completed by August 1970 with demilitarization operations completed by March 1971. Various technical and construction problems were encountered which resulted in at least twelve different schedules being established; an in-depth treatment of these schedule changes and the difficulties causing them is contained in the Edgewood Arsenal report, and therefore will not be reiterated here.[1] Section 7 details these revisions from the Cost standpoint.

6.5.2 SCHEDULE MODIFICATIONS

As described in previous sections, the alternate mustard disposal system, using the ton container furnaces, was essentially committed by June 1972. The preliminary

schedule established at that time was based on certain assumptions regarding burn rates and ton container drain weight.[2] It called for startup on 1 July 1972 and a burn rate of 1 GPM (0.7 GPM allowing for 30 percent operational downtime) which was to be followed by an increase in bulk rate to 2 GPM predicated on the use of both ton container furnaces and the new electrostatic precipitator and dryer in procurement at that time. This schedule was to terminate during May 1974 after a period of ton container burning to complete the destruction of the agent containers. However, this schedule was slipped to a start date (3-shift) of 21 August 1972 which resulted in a scheduled completion date for bulk agent of December 1973 to be followed by 5 months of ton container burning to terminate in June 1974.[3] During the 2 GPM phase starting in June 1973, there were to be no ton containers burned due to the projected use of both ton container furnaces for bulk agent disposal. This schedule indicated a first inflection point as of 1 June 1973, with a higher burn, at 245,000 gallons of agent (including T.C. residue). The second inflection point was at 31 December 1973, to a lower burn rate, at 493,000 gallons of agent (excluding T.C. residual burn). The terminal point of the schedule was 31 July 1974, at 608,000 gallons. This remained the same through 31 December 1972.

6.5.3 ALTERNATE ANALYSES

On 26 September 1972, the Program Manager for Demilitarization requested by message[4] that RMA analyze considerations pertinent to increasing the mustard disposal rate. On October 1972, RMA replied by message[5] that three alternatives had been examined. These alternatives were:

A. Use of the hydrazine furnace in Building 538. (This is the first official mention of the hydrazine furnace in correspondence.)

B. Replication of the existing ton container furnace agent incineration system.

C. Use of the Tailor System in Building 536.

The first alternative, hydrazine furnace, assumed a maximum spray drying capacity of 40 GPM; 30 GPM from the proposed Bower dryer and 10 GPM from the Tailor drying unit. It was assumed that a separate scrubber system would be needed for the hydrazine furnace which would be tied into the projected electrostatic precipitator. If this were done, it was estimated the cost would be approximately identical to the original schedule with the result that the one month's calculated decrease in schedule would be offset by the approximate costs. The assumed rate of burn under this alternative was 3.5 to 4.0 GPM. The second alternative was dismissed almost immediately due to the estimated cost involved in replicating the ton container furnaces as well as the additional scrubber system thought required at the time. Similarly, the Tailor System alternative was rejected due to the previous failure to make it operational and the unknown elements required in refurbishing and retesting it. Following an analysis of these alternatives, the decision was made to investigate the use of the hydrazine furnace without the additional scrubber system. The testing and operational introduction of the hydrazine furnace is discussed later in this section.

On or about 3 January 1973, the demilitarization schedule was changed as a result of a meeting at Picatinny Arsenal, New Jersey, on 19 December 1972. Details of this schedule are lacking, except for the end date of 9 June 1974, established for the program and the fact that the minimum disposal rate was set at 920 gallons per day (including ton container residue) and six ton containers per day in one furnace, both of these pertaining to Phase I only. The basic correspondence establishing this schedule[5] is in existence; but the inclosures containing the schedule are not readily available.

6.5.4 SCHEDULE FINALIZATION

The mustard disposal schedule finalized on 9 April 1973,[6] was the schedule employed, with one further modification, throughout the remainder of the program. The three phases remained as before; namely, Phase I (one GPM bulk plus ton containers), Phase II (two GPM bulk only), and Phase III (ton containers only). The 9 April 1973 schedule redefined the inflection points at the beginning of each phase based on the most current production data available at the time. This data had been developed prior to any vigorous production engineering efforts being employed in the program at RMA. The procedural schedule is shown in Figure 6–1. The end of Phase I was established as 30 May 1973, at a final total agent gallonage of 245,000 gallons (Point No. 5). This was determined by virtue of a schedule of 4536 gallons per week, 907 gallons bulk agent plus 6 ton containers per day. Phase II as set forth in this schedule was to terminate at 516,604 gallons on 28 November 1973, (Point No. 10). This phase required a minimum of 10,288 gallons per week or 2058 gallons of bulk agent per day. The incineration of containers in Phase III was to proceed at the rate of 12 containers per day, totaling 3500 pounds (350 gallons) of agent residue until program termination on 9 June 1974, at 608,435 gallons (Point No. 13). Each phase total schedule was composed of a bulk agent burn and a ton container burn schedules as shown in Figure 6–1. The gallonage figures were calculated from the original inventory expressed in pounds (6,084,350 pounds) using a factor of 10 pounds per gallon. In addition to establishing the above schedule, the Program Manager directed on 9 April 1973, that RMA examine the maximum disposal rates which could be achieved after installation of the new electrostatic precipitator (ESP) expected to occur on or about 1 May 1973. This directive was issued with the aim of examining a possible change to Phase II that would allow for disposal of ton containers along with the nominal two GPM bulk agent burn.

A directed action resulting from the 1 to 2 March 1973, Program Review Meeting at RMA, was that RMA would analyze the impact of changing from the then current five-day on, two-day off, schedule to a 10-day on, four-day off, schedule pending acceptance of the Bowen spray dryer. On 10 April 1973, RMA replied to this directed action.[7] Anticipated advantages of the 10 to four-day schedule were stated as the elimination of one startup and one shutdown cycle per two-week period, and the availability of longer maintenance periods during the four-day shutdown. The disadvantages considered were that due to the longer operating time of the

equipment between scheduled maintenance periods, more failures could be expected and an anticipated increase in the rate of absenteeism was expected to result from the imposition of this unpopular schedule. Decisive factors against the 10 to four-day schedule were stated as the then current shortening of the startup and shutdown periods and the completion of routine maintenance within the present two days time. RMA recommended that the 10 to four-day schedule be reserved for onetime use during longer scheduled shutdown periods for installation of new equipment. The Program Manager concurred in this decision on 4 May 1973.[8]

The analysis of the maximum disposal rate attainable with different combinations of the hydrazine furnace and ton container furnaces, with a view toward evaluating an alternate disposal schedule for Phase II, was to be presented for consideration at the 23 to 24 May 1973 Program Review Meeting held at RMA. In compliance with this directive, an alternative analysis was prepared by the RMA Mustard Demil Director and Process Engineer.[9] This analysis dealt with the maximum disposal rate observed under various furnace combinations and the use of these rates to present alternative schedules for Phase II involving simultaneous destruction of bulk agent and ton containers in the east ton container furnace. RMA recommended that the alternate schedule be approved based on (1) an overall schedule shortening and (2) allowing time to optimize the burning conditions for light residue and heavy residue ton containers. The Program Manager approved the change. On 15 July 1973, a letter[10] authorized the simultaneous destruction, during Phase II, of ton containers and bulk agent. A minimum destruction rate was set at 2000 gallons of bulk agent per day and, rather than a ton container schedule by number of containers, a residue burn rate of 175 gallons (nominal 1750 pounds per day) was defined. This resulted in a total minimum schedule of 2175 gallons of agent per operating day. The schedule began 1 June 1973. The ton container rate proved to be based on an underestimate of the average residue weight per ton container. This necessitated a further schedule change to upgrade the minimum residue poundage to be destroyed per day. The 2000-gallon per day minimum bulk agent burn represented a slight decrease in the minimum bulk burn set by the original 9 April 1973 schedule; however, this was more than offset by the residue to be incinerated.

To facilitate future scheduling of ton container incineration an estimate was made on 2 July 1973[11] of the number of ton containers of residue weight range 300 to 1800 pounds, arranged by 100-pound increments. The estimate was based on only H ton containers and utilized the agent drained weight from the 1332 ton containers emptied as of that date. The result of this estimate is covered in detail in the referenced document. A similar estimate was made on 16 July 1973, of the number of ton containers which the unload booths would not, for one reason or another, be capable of draining.

A short-range projection of Phase II completion was made on 14 September 1973, and specified 28 September 1973, as the target date. The actual date was 25 September 1973. This did not include CAMDS ton containers, bulk agent for west scrubber testing, or storage tank heels.

Phase III, incineration of the remaining ton containers, began on 25 September 1973, utilizing both ton container furnaces. The previously established Program Manager's schedule of 175 gallons (1750 pounds) of residue agent per day was doubled to account for the use of two simultaneously burning furances. On 5 September 1973, the Program Manager directed RMA to present a high confidence estimate of the date of Phase III completion. This estimate was prepared by 12 September 1973, by the Process Engineering Section.[12] A detailed discussion of this estimate will not be included here; the basis for calculation of the Phase III target dates is contained in the referenced document. The dates presented were 16 April 1974, for 100 percent operating time (no downtime) and 19 June 1974, for 70 percent operating time (30 percent downtime). It was felt at the time that (1) the dates were realistic, based on the confidence in the data used for calculation, and (2) the actual completion date would approach the 16 April 1974 figure based on the excellent equipment performance record established during Phase II of the program. Additionally, it was felt that the efforts of the heavy ton container studies to minimize container residence time could shorten the 16 April date. This was borne out by actual performance.

The Phase III completion estimates were updated on 11 October 1973, based on the results of the heavy ton container tests, and resulted in an optimistic date of 6 March 1974, and a pessimistic date of 28 March 1974, depending on the criteria used for the calculations.

During discussions held within the Mustard Demil Directorate at the end of Phase II, it was determined that the Program Manager's schedule of 3500 pounds of residue burned in both ton container furnaces per day would be inadequate to complete Phase III on the newly projected 16 April target date. This was based on a graphic extrapolation of the actual production versus schedule production on a larger scale version of Figure 6–1. It was decided to establish an internal RMA schedule for the minimum required poundage to be burned daily as 6000 pounds (total for both ton container furnaces).[13] This schedule was put into effect on 1 October 1973. Additionally, a calculation of the number of ton containers per day required to complete the schedule was made, and an additional internal operating schedule (for office use only) was set at 11 ton containers per day. However, it became apparent by 15 October that to schedule by poundage burned would not be as efficient as to schedule by numbers of containers incinerated per day. Therefore, the poundage requirement placed on the operations staff was dropped in favor of the 11-ton container per day internal schedule.

Reassessment on 1 November 1973 of the RMA internal ton container schedule resulted in the conclusion that to achieve the 16 April 1974 target date, only 8.4 containers per day minimum need be burned. In event that large residue weight container projections had been inaccurate, and that the 11-per day schedule could not be met, this recalculation reevaluated the minimum required to attain the estimated completion date. A graphic extrapolation of the performance data however, indicated that if the 11 per day rate were maintained, the completion date would be 6 March 1974, which coincided with the Phase III completion estimate made on 11 October 1973 and tended to support the assumptions made throughout the various estimates of Phase III completion.

Completion of the destruction of mustard agent ton containers at RMA occurred on 20 February 1974, thus predating all previous estimates. This completion excluded the 11 CAMDS ton containers, however. The last of these containers was incinerated in the CAMDS Test Program on 16 March 1974.

The internal RMA schedule for the ton container cut and scrape operation was established on 27 September 1973[14] to take effect on completion of a fume hood around the apparatus. This was completed on 6 October 1973, and the schedule of 16 containers per shift (48 per 24-hour day) established. Use of this minimum required production at the internal ton container incineration schedule of 11 per day would yield nearly simultaneous completion of the two schedules. An achievement date of 15 January 1974, was estimated dependent on continuation of the actual. average incineration rate of 15 containers per day. Thsi date was defined as the date on which the backlog of ton containers burned prior to startup of the cut and scrape operation would be reduced to zero, and the cut and scrape operation would be required to keep pace only with the containers burned on each operating day.

6.6 SUMMARY OF OPERATIONAL STATISTICS, PERFORMANCE AGAINST SCHEDULES

The schedule finalized on 9 April 1973 was the schedule against which the actual performance of the demilitarization operation was measured. Reference to Figure 6–1 gives an overview of each phase of the actual disposal operation contrasted with the schedule.

6.6.1 PHASE I

Phase I of the program was to incorporate bulk agent incineration at one gallon per minute with 30 percent operational downtime. This equated to 907 gallons of bulk agent per day. The overall disposal rate, utilizing 30 percent downtime, was scheduled to be approximately 0.7 GPM; however, the effective disposal rate was expected to be 1.0 GPM utilizing the available operating time less the 30 percent expected downtime. The end of Phase I was set at 30 May 1973 and was a calendar date endpoint rather than a "gallons destroyed" endpoint.

The total bulk agent destroyed during Phase I (see Table 6–4) was approximately 161,488 gallons, which equates to an overall disposal rate "through the nozzle" of 0.61 GPM and an effective disposal rate of 0.81 GPM. This rate was somewhat less than that expected of the system but would have been worse had the hydrazine furnace not been brought onstream early, and had it not been as effective and problem-free as it proved to be. The downtime problems experienced with the west container furnace bulk burning system (see Table 5–1) specifically, limited flow rate, and nozzle plugging problems, were, in large part, avoided by not replicating the existing system in the east container furnace as had been planned. The agent disposal rate in the hydrazine furnace had to be cut back toward the end of Phase I to attempt a decrease in the rate of deterioration of the scrubber exhaust fans.

Ton container incineration during Phase I (see Table 6–5) was ahead of schedule on the average. There were 1191 containers incinerated in 185 operating days with a total of 234,676 pounds of residue destroyed. Averages for Phase I were 6.4 containers per day, 1269 pounds of residue per day, and 187 pounds of residue per container. There were 5 months out of the 10 months of Phase I in which the number of containers burned was less than the scheduled 6.0 per day. The increase in he average number of containers per day during the February to May time period was due in large part to the great number of containers of HD drained during January, February, and March which were incinerated in preference to larger residue containing H containers as can be seen in Table 6–5.

The overall effect of the disposal operation during Phase I was that by 30 May 1973, the program was at a cumulative agent destroyed value which had not been forecast to occur until the first week of July 1973. It is obvious from the actual agent disposal curve on Figure 6–1 that the disposal had paralleled the scheduled incineration rate until the beginning of February; however, the all-HD incineration during February and the introduction of the hydrazine furnace during March had the effect of making up the small schedule/actual deficit on or about 15 February and of moving actual incineration well ahead of schedule to the extent of 50,736 gallons (507,350 pounds) approximately by the 30 May phase termination date. Ton container residue incineration did not measureably add to this accelerated burning rate despite the larger average number burned per day from February through May since the average residue weight per container decreased considerably.

6.6.2 PHASE II

Phase II of the program was to incorporate bulk agent incineration at two gallons per minute with 30 percent operational downtime in addition to ton container incineration. This rate required a minimum agent burn per week of 10,875 to be made up of 2000 gallons of bulk agent and 175 gallons (1750 pounds approximately) of ton container residue per operating day. The termination point of Phase II was to be 30 November 1973 according to the 9 April schedule; this was moved up to 15 October on the revised Phase II schedule (15 June 1973). The gallonage endpoint was to have been 516,000 gallons on 30 November but this was adjusted to 488,000 gallons at the 15 October end date based on revised estimates of the amount of bulk agent being drained from H type ton containers.

The total bulk agent destroyed during Phase II was approximately 194,213 gallons over an 81-day operating period for an average of 2,397. The overall disposal rate "through the nozzle" was 1.67 gallons per minute while the effective rate was 1.82. The overall rate was approximately equal the 1.7 GPM rate scheduled using a zero percent downtime available time calculation; however, the effective rate was somewhat less than the 2.0 GPM rate expected with an estimated 30 percent downtime, despite the fact that the actual downtime averaged 8.5 percent more than the downtime of Phase II. Individual daily effective burn rates exceeded 2.5 GPM. This daily rate was strongly influenced by the characteristics of the agent being incinerated at that time, i.e., the amount of fuel oil in the agent and the varying sulfur content. The average daily rate was at 2398 gallons, which excessed the scheduled gallonage of 2000 per day.

Ton container incineration during Phase II (see Table 6–5) was considerably ahead of the 1750 pounds per day schedule in that a total of 167,605 pounds (approximately) of residue were incinerated in the 81 operating days of Phase III (through 25 September 1973) resulting in an average daily residue destruction rate of 2069 pounds, which, when converted to the basis of GPM, yielded an additional 0.16 GPM to the total agent destruction rate. The daily container incineration rate on the average for Phase II was 8.2 containers per day which indicated an increase over Phase I rates at comparable average residue weights. The data in Table 6–5, which shows an average incineration rate for June and July of 10.3, was due to the effects of the ton container furnace residence time optimization effort during June. The average rate during August and September of 6.2 containers per day was the result of the testing for, and implementation of, the heavy residue weight ton container burning procedure as evidenced by the fact that the average residue weight per container during this 39-day period was 341 pounds.

The overall effectiveness of the disposal operation during Phase II is indicated in Figure 6–1. The incineration was ahead of the established schedule throughout the entire length of Phase II by a consistently widening margin. At the point on 25 September 1973, which marked the completion of bulk agent incineration, a total of 510,400 gallons of agent had been incinerated since the beginning of the program (including Tailor System shakedown). This was approximately equal to the end point of the 9 April Phase II schedule and 22,400 gallons ahead of the 15 June Phase II schedule. Phase II was thus completed approximately three weeks ahead of the 15 June schedule, and approximately 9 weeks ahead of the 9 April schedule.

6.6.3 PHASE III

Phase III of the Program was intended to dispose of the residue ton containers which had not been incinerated during Phases I and II. The scheduled rate established (3500 pounds per day) in the original 9 April schedule was not applicable, and an internal operating schedule was established based on the actual gallonage destroyed at the end of Phase II and a selected completion date of 16 April (6000 pounds per day). However, the internal RMA schedule was shortly changed to an 11-container per day requirement to complete the Phase on 16 April.

The bulk agent burned during Phase III was confined to: (1) agent retained beyond 25 September 1973 in order to test the west scrubber system on bulk agent at the completion of its installation during early November; (2) agent drained from CAMDS ton containers not used in testing; and (3) agent drained from heavy ton containers which had been redrained through a plug adapter. A total of 13,789 gallons were destroyed in this manner.

Ton container incineration during Phase III was resumed against two schedules (Figures 6–1 and 6–2). The first consisted of the performance against the original GPM schedule which projected the completion on 9 June 1973. The second schedule applied was the internal RMA schedule of 11 ton containers per day, total for both ton container furnaces. As can be seen from Figure 6–1, the actual performance of the Phase III operation in terms of residue burned stayed consistently ahead of the

two schedule projections made and phase endpoint estimate. Of the 5 months comprising Phase III, only February 1974 failed to average more than 11 containers per day; however, February had the largest average container residue weight averages for east and west furnaces experienced throughout the program.

The overall effectiveness of the demilitarization operation during Phase III can be gaged by the fact that when the last container of the mustard stockpile to be incinerated (except for CAMDS test containers) was based on 20 February 1974, the program was completed approximately 13 weeks ahead of the 9 June endpoint and approximately 54 and 14 days ahead of RMA's internal schedule estimates of 6 March and 16 April, respectively. A total of 505,467 pounds of T.C. residue was destroyed during the same period. (Reference Table 6–6.)

The ton container cut and scrape operation was started at the beginning of Phase III and was co-terminal with the demilitarization operation. A total of 3283 ton containers were cut and scraped during Phase III. The remainder of the 3407 ton containers had been either cut as trash receptacles or used to test the cutting apparatus during construction and shakedown. The scraping operation generated 965 barrels of ash which was ultimately disposed of by dry land dilution.

6.7 CAUSTIC USAGE AND SALT/RESIDUE GENERATION

Caustic usage during the Mustard Demilitarization Program is shown in Table 6–7. A total of 4339 tons of caustic soda (100 percent NaOH) were used throughout the program. Average caustic usage per pound of agent or residue burned was approximately 1.37 pounds. The sodium hydroxide solution was purchased as 50 percent aqueous solution in railroad tank cars. These tank cars were unloaded at the Mustard Facility at a caustic unloading station located at the north end of the Building 538 storage yard. The 50 percent solution was diluted to 18 percent with process water in the 1000-gallon upright caustic tanks located south of Building 538. Caustic costs were approximately $100.00 per ton of 50 percent solution.

Accurate data on salt production during the program is not available due to the fact that salt generated prior to the start of the Bowen spray dryer was, for the most part, hauled in closed dump trucks to a warehouse where it was deposited on the floor in bulk. No weight records were kept of this material. Using as a standard the ratio of 2.3 pounds of salt produced per 1.0 pound of agent incinerated, which was developed month-by-month from salt generation data available, a total of approximately 14,000,000 pounds (7,000 tons) of salt was produced. Recognizing losses that occurred early in the program, the number of barrels used for the salt produced was 19,072 drums. It is estimated that an additional 1500 to 2000 tons of bulk salt is stored, uncompacted, in warehouses. Other ratios developed over the course of the program which relate to the spray drying operation are that approximately:

A. 1.84 gallons of brine at 1.15 specific gravity was produced by the incineration of 1 pound of agent.

B. One gallon of agent per minute equaled 19.5 gallons of brine per minute at 1.15 specific gravity.

C. One gallon of brine at 1.15 specific gravity yielded 1.25 pounds of salt.

There were approximately 965 barrels (222,063 pounds) of ton container ash generated by the cut and scrape operation. This material was stored in a warehouse until its ultimate disposal by dry land dilution. This poundage was "wet" weight in that the material was weighed after it had been barrelled and after it had been soaked with water to stop the smoldering caused by the cutting operation. Only second-hand drums were utilized to store this material. Each drum was stencilled with its lot number and sequential number.

There were a total of approximately 421 drums (63,158 pounds) of iron oxide residue removed from the ESP between 1 May 1973 and 20 February 1974. All iron oxide generated prior to that time had been disposed of in the RMA sanitary land fill at the direction of the Chief of the RMA Quality Assurance Office. The material collected from the ESP after 1 May 1973 was stored in a warehouse and ultimately disposed of by dry land dilution.

6.8 OVERALL PROGRAM PERFORMANCE

There was a total of approximately 3,909,609 pounds of bulk mustard agent destroyed during the ton container furnace/hydrazine furnace portion of the overall Project Eagle I. The ton container total residue burned of approximately 919,103 pounds and the CAMDS container test program agent destroyed of approximately 19,800 pounds, indicates a grand total of approximately 4,848,512 pounds of agent were destroyed between 21 August 1972 and 18 March 1974. The figures used are approximations since tank outage readings for bulk agent burned were recorded in gallons and converted to pounds using an approximate density of 10 pounds per gallon. Ton container drain data however, shows that a measured 3,839,657 pounds of agent were drained into the storage tanks to be burned as bulk agent. Therefore, the bulk agent figures derived from both sources agree to within the accuracy of the measuring methods used. Additionally, sufficiently reliable drain and bulk burn data was lacking for the early portions of the program. When the 993,918 pounds of agent and residue estimated to have been burned during the Tailor System operations is added to the grand total shown above, final agent destruction figure of 5,842,430 pounds of agent is arrived at which agrees with the inventory poundage of 584,000 pounds within acceptable accuracy. At the completion of the program on 16 March 1974, there was no stockpile mustard agent located at Rocky Mountain Arsenal with the exception of storage tank heels to be chemically decontaminated during plant cleanup operations.

The total number of ton containers incinerated during Project Eagle I, excluding Tailor System shakedown, was 3407; 2423 in the east furnace and 900 in the west furnace. The remainder of the 3407 stockpile containers were incinerated during the testing of the Building 538 ton container decontamination system as part of the earlier Tailor incineration system.

The combined ton container/hydrazine furnace demil system went ahead of established schedules on or about 15 February 1973 and remained ahead of not only the externally established schedule, but far ahead of more stringent internal schedules for the next 370 days with a final completion which occurred 13 weeks prior to its estimated end but 35 months behind the original Project Eagle schedule which called for a March 1971 completion date.

REFERENCES

[1]EA Special Report EASP, titled: "Bulk Mustard Demilitarization at Rocky Mountain Arsenal April 1969 through September 1972", dated Jun 1974 by Mr. Leonard M. Lojek, pages 58 and 60.

[2]RMA Telecon Record, dated 13 Oct 1972, subject: "Bulk Agent Assumptions, and Rate Calculations for Mustard Program".

[3]AMXDC TWX to RMA, dated 26 Sep 1972, subject: "Effects of Concurrent Demil Operations".

[4]SMURM-CO TWX to MUCOM, dated 2 Oct 1972, subject: "Effects of Concurrent Demil Operations".

[5]AMXDC Letter to RMA, dated 22 Jan 1973, subject: "Mustard Demil Schedule".

[6]AMXDC-O Letter to RMA, dated 9 Apr 1973, subject: "Schedule for Mustard Disposal at Rocky Mountain Arsenal".

[7]SMURM-O-P Letter to MUCOM, dated 10 Apr 1973, subject: "Alternate Schedule Tour of Duty for Mustard Operation".

[8]AMXDC-O Letter to RMA, dated 4 May 1973, subject: same as above.

[9]SMURM-M Paper, dated 24 May 1973, on Phase II Burn Schedule Alternatives.

[10]AMXDC-O Letter to RMA, dated 15 Jun 1973, subject: "Mustard Disposal Schedule".

[11]SMURM-M Letter to PM, dated 2 Jul 1973, subject: "Reply to Directed Action".

[12]SARRM-M Letter to PM, dated 12 Sep 1973, subject: "Estimate of Phase III Completion".

[13]SARRM-M DF to Chief Engineer, dated 27 Sep 1973, subject: "Ton Container Disposal".

[14]SARRM-M DF to Chief Engineer, dated 27 Sep 1973, subject: "Ton Container Cut and Scrape Operation Schedule".

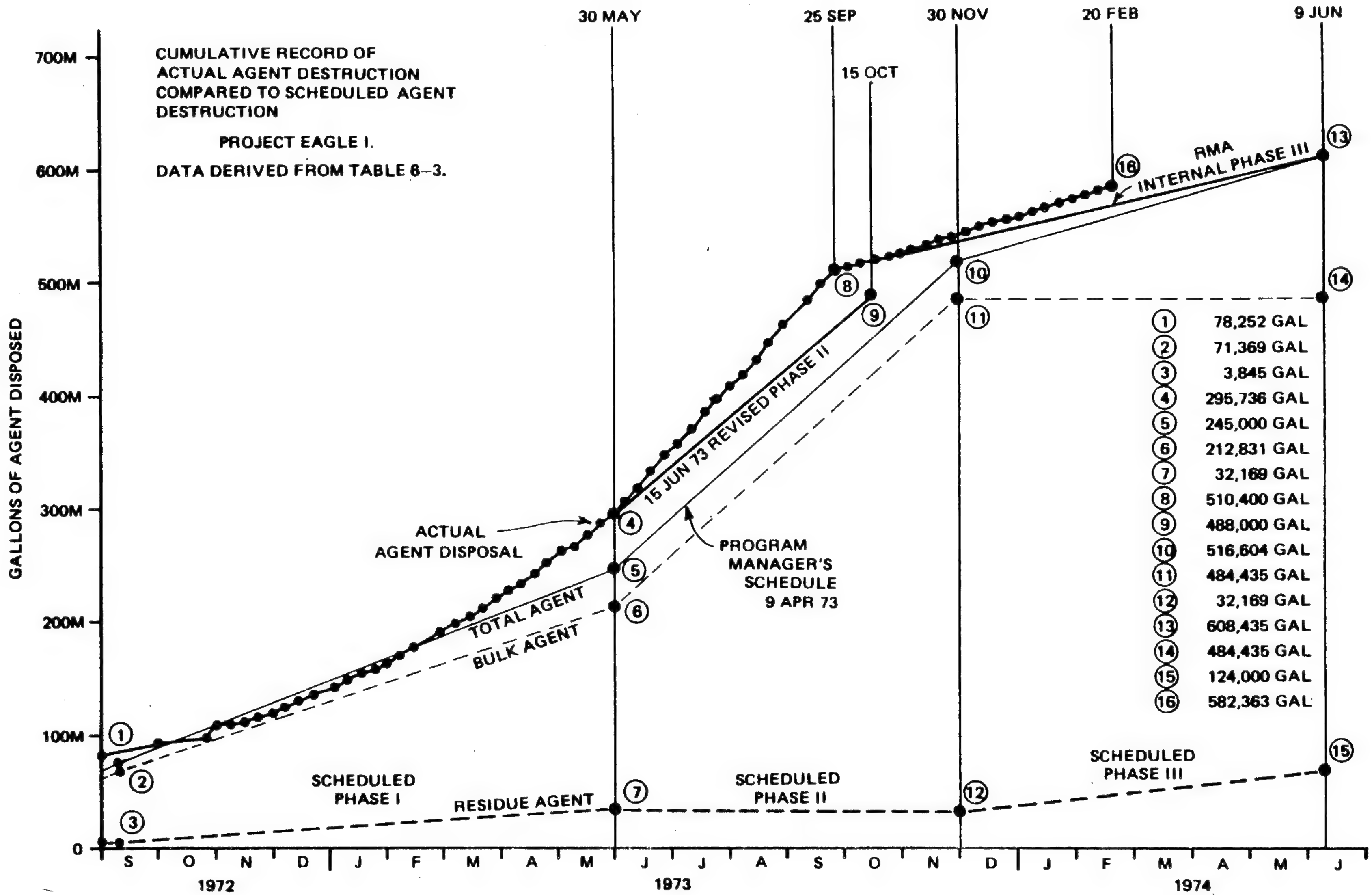


FIGURE 6–1. CUMULATIVE RECORD OF AGENT DESTRUCTION

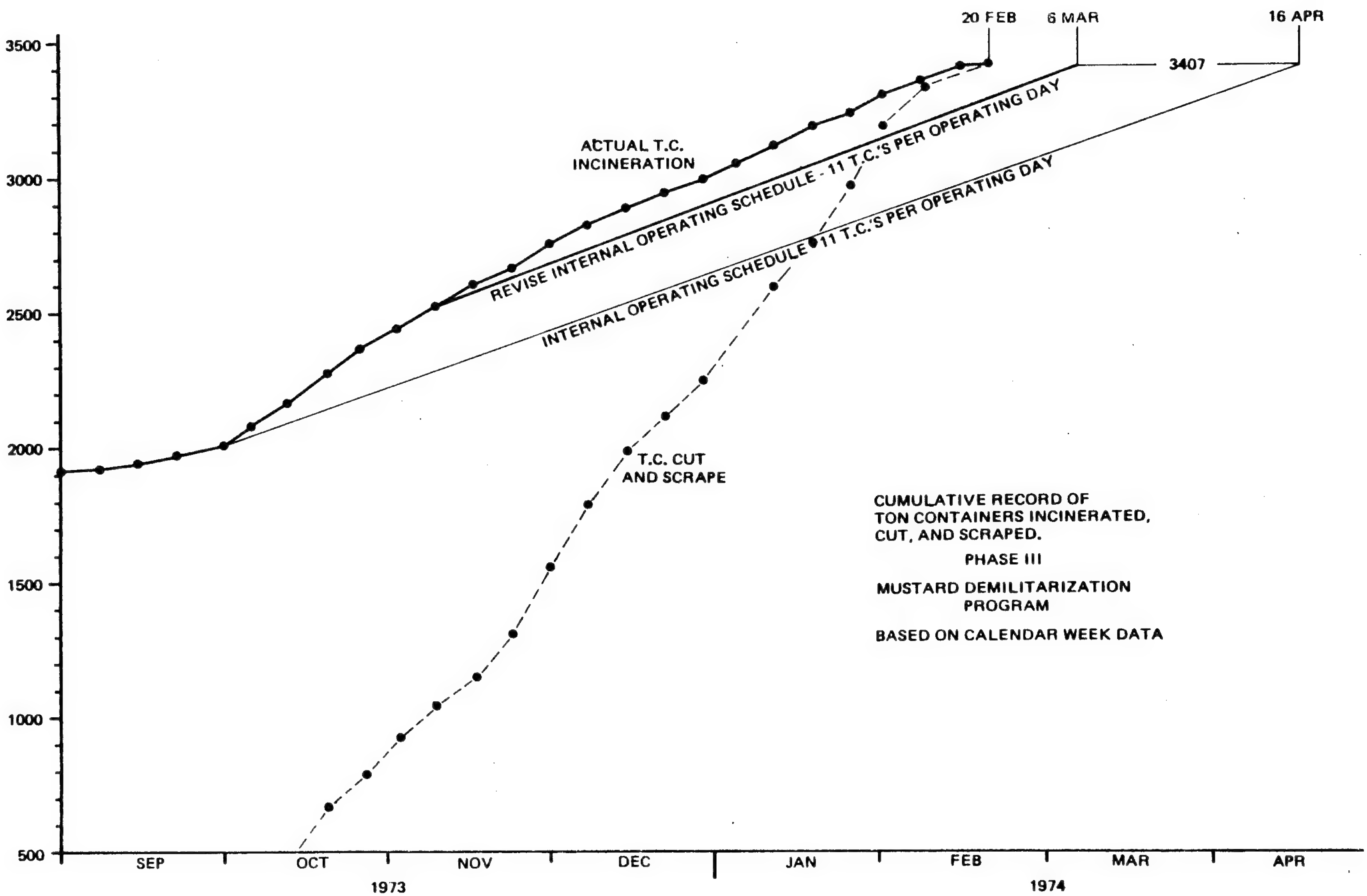


FIGURE 6–2. CUMULATIVE RECORD OF TON CONTAINERS INCINERATED

FORM OR REPORT TITLE	CONTENTS	MAJOR USE	FREQUENCY
1. B-537 Log Book	Operational entries, vac. pump and water pH, charcoal filter pressure drops, bubbler readings, serial nos. of T.C.'s delivered from storage, mustard pump pressures	Inventory and Process Control	By shift, daily and as required
2. Shift Engineer Log Book	Operational entries, instructions from manager, engineer's comments	Process Control	As required
3. Mustard T.C. Unloading SMURM Form 0-24 (until Jun 73)	Serial & lot nos., fill date, weight data, cubicle used, receiver tank	Inventory Control	Form by shift, entries by container
4. Mustard T.C. Unloading SMURM Form 0-24 Rev 1 (after Jun 73)	As in SMURM Form 0-24 plus storage tank outage readings	Inventory Control	By shift, tank readings each hour
5. Quality Assurance Form, H & HD Container Data Card (No form no.)	T.C. fill date, weight data, burn data	Inventory Control	One per container for transfer and decontamination
6. Mustard Tank Readings SMURM Form 0- (until Jun 73) (no example available)	Mustard tank outage readings	Inventory and Process Control	Form by shift readings each hour
7. Ton Container Decontamination SMURM Form 0-29 (until Jun 73) (no example available)	Furnace, T.C. serial no. type of agent, weight data, time/temp data	Inventory and Process Control	Form daily, entries by container

Table 6–1. PLANT GENERATED DATA SHEETS AND PRODUCTION REPORTS (Sheet 1 of 3)

FORM OR REPORT TITLE	CONTENTS	MAJOR USE	FREQUENCY
8. Ton Container Decontamination SMURM Form 0-29, Rev 1	Same as Form 0-29	Inventory and Process Control	Form daily, entries by container
9. B-538 Ton Container Furnace and Hydrazine Furnace Log Book	Time and serial number entries, operational entries	Inventory and Process Control	Entries as required
10. Container Cut and Scrape Logbook, B-540	Container serial numbers, ash drum lot and barrel numbers	Inventory and Process Control	Entries by container
11. Spray Dryer Logbook B-540	Spray dryer operational entries	Process Control	Entries as required
12. East Scrubber Logbook	Operational entries	Process Control	Entries as required
13. Electrostatic Precipitator Logbook	Operational entries, ESP residue drum quantity and drum weights	Inventory and Process Control	Entries as required,
14. West Scrubber Logbook	Operational entries	Process Control	Entries as required
15. QA Monitoring Station Logbook	Monitoring system data	Process Control	Entries as required
16. Daily Summary Report by Shift Engineer - 2 Forms (no form no. prior to Dec 72) (SMURM Form 0-31 after Dec 73)	T.C. emptied data, T.C. burned data, downtime, bulk agent burn data, salt barrels and poundage, empty salt barrels required	Inventory and Process Control	Daily to Production Control
17. Daily T.C. Decontamination Summary Report by Shift Engineer	T.C. burn and cut data by furnace	Inventory and Process Control	Daily to Production Control

Table 6–1. PLANT GENERATED DATA SHEETS AND PRODUCTION REPORTS (Sheet 2 of 3)

FORM OR REPORT TITLE	CONTENTS	MAJOR USE	FREQUENCY
18. Hydrazine Furnace Data Sheet, (No SMURM no.)	Furnace operational data, pressures, temperatures, mustard flow per hour	Process Control	Form daily entries each hour
19. East Flue Gas Quench Data Sheet (No SMURM no.)	Gas and liquid temperatures, pressures, alkalinity, density, vessel levels, etc.	Process Control	Form daily entries each hour
20. East Scrubber and Precipitator Data Sheet (No SMURM no.)	Gas and liquid pressures, temperatures, heat exchanger temperatures, alkalinity, densities, etc.	Process Control	Sheet daily, entries each hour
21. West Quench/Scrubber Data Sheet (No SMURM No.)	Similar to items 20 and 21	Process Control	Sheet daily, entries each hour
22. Bowen Spray Dryer Data Sheets (No form no.) (no examples available)	Operational data, temperatures, pressures, liquid flow rates	Process Control	Sheet daily entries each hour
23. Request for Issue or Turn-In (DA Form (3161)	Serial numbers of cut containers released for sale, verification of absence of agent by incineration	Inventory Control	Daily
24. Hazardous Work Permit (SMURM SAF-16)	Request for and approval of work to be performed in agent areas	Safety Documentation	As required
25. Ton Container Furnace Time/Temperature Charts	24-hour time chart of ton container, furnace temperature. Includes T.C. serial number and weight data	Process Control	Continuous 24-hour entries by container

Table 6–1. **PLANT GENERATED DATA SHEETS AND PRODUCTION REPORTS (Sheet 3 of 3)**

MUSTARD TON CONTAINER UNLOADING - BLDG. 537

DATE: ____________ SHIFT: ____________

No.	T.C. Ser. No.	Lot No.	Date Filled	Skin Temp.	Gr. Wt. Before Transfer	Gr. Wt. After Transfer	Wt. Mustard Transfer	Stencil Weight Mustard in T.C.	Weight Residue in T.C.	Storage tank used as Receiver	Unload Cubicle Used	Actual Transfer Time
1.												
2.												
3.												
4.												
5.												
6.												
7.												
8.												
9.												
10.												

ITEM 3

H & HD CONTAINER DATA CARD

DATE: ____________________ SERIAL NO. ____________________

INFORMATION TAKEN FROM ONE TON CONTAINER:

TYPE AGENT	LOT NO.	DATE FILLED	GROSS WT	TARE WT	NET WT

*ACTUAL WEIGHTS

BEFORE TRANSFER* ______________ AFTER TRANSFER ______________ TARE WT ______________

AFTER TRANSFER* - ______________ TARE WT - ______________ WT AFTER BURN* - ______________

MATERIAL TRANSFERRED [ ] WT OF RESIDUE [ ] WT OF ASH [ ]

BLUE BAND TEST RESULTS: ____________________ MARKING CHECK RESULTS ____________________

REMARKS:

SIGNATURE: ______________________________ DATE: ______________________________

QA REPRESENTATIVE FINAL ACCEPTANCE

ITEM 5

DAILY PROGRESS REPORT

DATE ________________

	EAST FURNACE	WEST FURNACE	TOTAL
1...POUNDS OF RESIDUE BURNED....			
2. T.C.'s BURNED(H).............			
3. ...T.C.'s BURNED(HD).........			
4.....DOWN TIME.................			

5...T.C.'s CUT IN HALF.. ________

6...BARRELS OF ASH.. ________

7...SALT HAULED... ________

8...SALT BARRELS NEEDED... ________

9...PALLETS NEEDED.. ________

10...T.C.'s NEEDED FOR CUTTING................................... ________

11...T.C.'s NEEDED FOR BURNING.................................. ________

12...OXYGEN & ACETYLENE ON HAND........................ O________ A__________

13...CAUSTIC INVENTORY
TANK CAR NO.____________.........AMOUNT__________
TANK CAR NO.____________.........AMOUNT__________
TANK CAR NO.____________.........AMOUNT__________

SARRM Form 0-31 (4Dec73) **ITEM 16**

DATE: ____________

SHIFT: ____________

SUPERVISOR: ____________

NO.	T.C. SER. NO.	LOT NO.	FILL DATE	MAT'L	SKIN TEMP.	GR.WT. BEFORE TRANSFER	GR.WT. AFTER TRANSFER	WT. MUSTARD TRANSFER	STENCIL WEIGHT MUSTARD IN T.C.	WEIGHT RESIDUE IN T.C.	STORAGE TANK USED	UNLOAD CUBICLE USED	MUSTARD STORAGE TANK READINGS					
													TIME	TANK	MEASURE	GALLONS	GALLONS USED	TOTAL
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		

HYDRAZINE FURNACE

DATE: ____________

SHIFT: ____________

SUPERVISOR: ____________

TIME	PERCENT OPENING			FURNACE ΔP	TEMPERATURES			PRESSURES							GALLONS MUSTARD BURNED	TOTAL
	AIR DAMPER	NAT. GAS VALVE	MUSTARD VALVE		STACK	COMB. CHAMBER	FURNACE	COMB. AIR	ATOM. AIR	NAT. GAS	MUSTARD NO. 1	MUSTARD NO. 2	MUSTARD NO. 3			

ITEM 18

DATE: ____________________

SHIFT: ____________________

SUPERVISOR: ____________________

TIME	GAS			CAUSTIC		BRINE					QUENCH SPRAYS									
											PRESSURES					FLOWS				
	TEMP IN	PRESS IN	QUENCH PRESS	LEVEL	FLOW	pH	LEVEL 536	LEVEL 538	PUMP PRESS	TEMP TO SCBR	TOP	2ND	3RD	BOT'M	DUCT	TOP	2ND	3RD	BOT'M	DUCT

ITEM 19

EAST SCRUBBER/PRECIPITATOR

DATE: ____________________

SHIFT: ____________________

SUPERVISOR: ____________________

TIME	SCRUBBER GAS				BRINE			HEAT EXCHANGER TEMPS				ELECTROSTATIC PRECIPITATOR								
	TEMP IN	TEMP OUT	PRESS IN	PRESS OUT	pH	SP.GR.	RECIRC PUMP PRESS	BRINE		WATER		TEMP IN	TEMP OUT	PRESS IN	PRESS OUT	PRESSURE DROPS				
								IN	OUT	IN	OUT					1	2	3	4	5

ITEM 20

DATE: ______________________

TIME	PRESSURE					QUENCH RINGS										COLD WATER		CAUSTIC				TEMP				HEAT EXCHANGER				PUMP PRESSURE		
	QUENCH TOWER INLET	QUENCH DUCT	SCRUBBER TOWER OUTLET	PRECIPITATOR OUTLET	STACK	1		2		3		4		5		6		QUENCH DUCT pH		QUENCH TOWER FLOW	SCRUBBER TOWER FLOW	QUENCH		SCRUBBER		BRINE		COLD WATER		RECIR PUMP PRES	DISCH PUMP PRES	QUENCH BRINE PUMP PRES
						FLOW	PRES	FLOW	PRES	FLOW	PRES	FLOW	PRES	FLOW	PRES	FLOW	PRES					IN	OUT	IN	OUT	IN	OUT	IN	OUT			

ITEM 21 QUENCH SCRUBBER NO. 12

REQUEST FOR ISSUE OR TURN-IN
For use of this form, see AR 711-16; 735-35; the proponent agency is Office of the Deputy Chief of Staff for Logistics.

ISSUE	
TURN-IN	X
SHEET NO.	1
NO. SHS	
5. REQUEST NUMBER	
1. FROM	MUSTARD DEMIL THRU: SUPPLY DIVISION
6. DATE MATERIEL REQUIRED	
7. PRIORITY	
2. TO	PROPERTY DISPOSAL (DPDO)
8. VOUCHER NUMBER	W51G2F-3316-M086
9. POSTED	DATE / BY; DATE / BY
3. ACCOUNTING AND FUNDING DATA	ACCT. 1373
4. END ITEM IDENTIFICATION	a. NAME AND MANUFACTURER; b. MODEL; c. SERIAL NUMBER; d. PUBLICATION

ITEM NO. a	STOCK NUMBER, DESCRIPTION, AND CODING OF MATERIEL AND/OR SERVICES b	CODE* c	UNIT OF ISSUE d	QUANTITY e	SUPPLY ACTION f	UNIT PRICE g	TOTAL COST h
	8120-292-9663 CONTAINER, TYPE D, MUSTARD DEMIL SCRAP	X	EA	11			

SERIAL NO"S.

D-11131	D-23077
D-47741	D-3663
D-1167	D-82154
D-56738	D-24316
D-86150	D-2790
D-2268	

THE ABOVE LISTED ITEMS HAVE BEEN DEMILITARIZED BY CUTTING AND BURNING.

"I CERTIFY THAT THE PROPERTY LISTED HEREON HAS BEEN INSPECTED BY ME AND, TO THE BEST OF MY KNOWLEDGE AND BELIEF, CONTAIN NO ITEMS OF A DANGEROUS NATURE."

12-21-72

DATE

QA INSPECTOR'S SIGNATURE

SHEET TOTAL

GRAND TOTAL

*ISSUE - I-Initial; R-Replacement TURN-IN - U-Unserviceable; S-Serviceable

10. ISSUE OR TURN-IN OF QUANTITIES IN "QUANTITY" COLUMN IS REQUESTED	DATE	BY A.G. SANDBERG DIR. MUSTARD DEMIL	11. RECEIVED QUANTITIES IN "SUPPLY ACTION" COLUMN	DATE	BY

DA FORM 3161 1 JUL 66 REPLACES DD FORM 1150-1, 1 OCT 57, WHICH MAY BE USED. ☆ GPO: 1969 — 343-784/568

ITEM 23

HAZARDOUS WORK PERMIT
(RMA Reg 385-1)

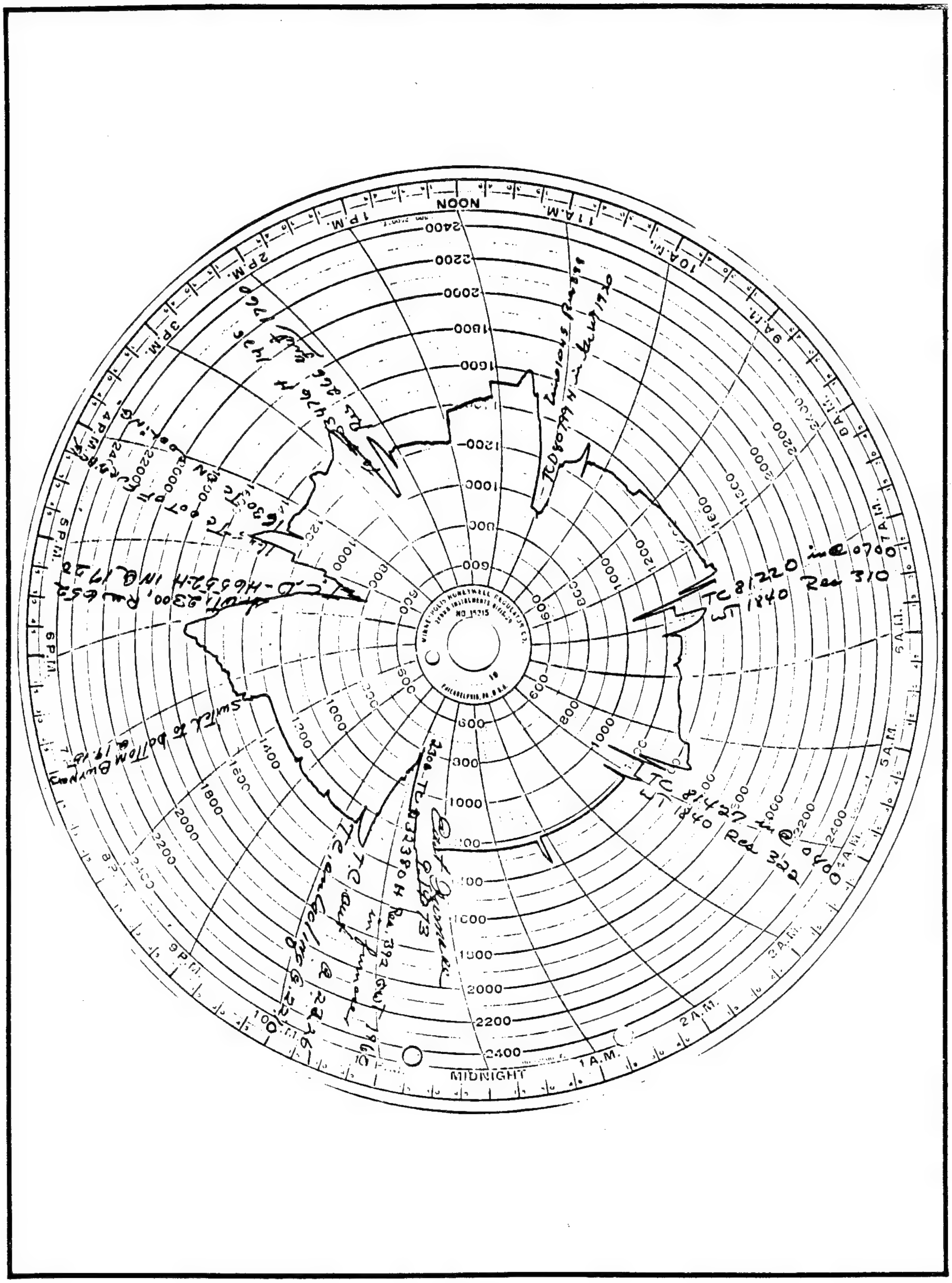
1. REQUESTING ACTIVITY DATE SIGNATURE
2. DATE & TIME WORK TO BEGIN
3. LOCATION OF WORK
4. NATURE OF WORK
5. SPECIAL INSTRUCTIONS
6. SPECIAL PREPARATIONS
7. PERSONAL PROTECTION REQUIRED

1. SERVICING ACTIVITY DATE SIGNATURE
2. SOP OR JHA NO. & TITLE
3. NAME OF SUPERVISOR WORKERS
4. SPECIAL EQUIPMENT REQUIRED
5. SAFEGUARDS
6. SPECIAL REQUIREMENTS OR TEST

1. SAFETY OFFICE REPRESENTATIVE DATE SIGNATURE
2. CONCURRENCE/COMMENTS

SMURM SAF-16 (20 Apr 72)

ITEM 24



ITEM 25

FORM OR REPORT TITLE	CONTENTS	ORIGINATING OFFICE	MAJOR USE	FREQUENCY
1. Daily Production T.C.'s emptied (SMURM Form 0-28)	T.C. agent transfer data	Mustard Demil Production Control	Inventory Control	Daily
2. Ton Container Decontamination	T.C. incineration data	Mustard Demil Production Control	Inventory Control	Daily
3. Manufacturing Div Progress Report (SMURM Form 0973)	Daily summary of plant production	Mustard Demil Production Control	Inventory Control	Daily to Ch Engr
4. Overall Progress Chart	Agent and residue destroyed expressed as GPM - bar chart used until 25 Sep 73 - Type 1 for office use - Type 2 posted in plant & office	Mustard Demil Production Control	Process Control	Posted daily
5. T.C. Residue Progress Chart	Time series of total T.C. residue burned and T.C.'s incinerated, boty vs schedule	Mustard Demil Process Engineering	Process Control	Posted daily
6. Average Residue Burned per Ton Container	Time series of average residue burned per container per furnace, number of H mustard T.C.'s per furnace	Mustard Demil Process Engineering	Process Control	Posted daily
7. T.C. Residue Burned Cumulative progress chart	Time series of cumulative residue burned vs. schedule	Mustard Demil Process Engineering	Process Control	Posted daily
8. T.C. Incineration and cut/scrape cumulative progress chart	Time series of cumulative residue burned vs. schedule	Mustard Demil Process Engineering	Process Control	Posted daily

Table 6–2. PRODUCTION CONTROL FORMS, REPORTS, PROGRESS CHARTS (Sheet 1 of 3)

FORM OR REPORT TITLE	CONTENTS	ORIGINATING OFFICE	MAJOR USE	FREQUENCY
9. Weekly Status Report Disposition Form	Detailed extract of operation logs, weekly summary of containers emptied and burned, monthly downtime summary at end of month	Mustard Demil Process Engineering	Process Control	Calendar weekly to Ch Engr
10. Weekly Progress Report Message	Summary of weekly production downtime and system modifications	RMA Ch Engineer	Process Control	Thurs-Wed weekly to Pgm Mgr AMXDC-O
11. Monthly Caustic Usage	Month ending inventory, current inventory, receipts to compute usage	Mustard Demil Production Control	Process Control	Monthly to Log svcs & Compt
12. Program Progress Chart	Cumulative agent destroyed vs. schedule	Mustard Demil Process Engineering	Process Control	Posted weekly from Item No. 10
13. Monthly Feeder Report	Production summary for month	Mustard Demil Production Control	Work Measurement	Monthly to Compt
14. RMA Demilitarization Report	Narrative summary of month's production, downtime, modifications, accomplishments, projection of following month milestones	RMA Ch Engr	Project Mgmt	Monthly to Pgm Mgr, AMXDC-O
15. Commander's Quarterly Review & Analysis	Quarterly, review of program's progress	Mustard Demil	Cmd Management	Quarterly to RMA Cmdr
16. Earned Hour Report	Effectiveness of work performed	Comptroller	Project Management	Monthly from Comptroller
17. Cost Reports	Actual costs against program, daily labor hours, leave usage, etc.	Comptroller	Project Management	Monthly from Comptroller

Table 6–2. PRODUCTION CONTROL FORMS, REPORTS, PROGRESS CHARTS (Sheet 2 of 3)

FORM OR REPORT TITLE	CONTENTS	ORIGINATING OFFICE	MAJOR USE	FREQUENCY
18. ADPE No. 9905, H-HD Container and Burn Data	Computer printout summary of data from QA T.C. data cards	Data Processing	Inventory Control	Weekly to QA
19. Bubbler Results (Form 1222)	Results of bubbler samples taken in plant, specific gravities/and mustard content of brine samples	QA Lab	Process Control	Daily to Mustard Demil
20. BiWeekly Roster	List of Personnel	Mustard Demil	Personnel	BiWeekly
21. Punch List	Maintenance Task List	Mustard Demil	Maintenance	Weekly
22. Preventive Maintenance Program Check Sheet	List of Preventive Maintenance Tasks for each piece of equipment	Maintenance Office	Maintenance Personnel	Weekly

Table 6–2. PRODUCTION CONTROL FORMS, REPORTS, PROGRESS CHARTS (Sheet 3 of 3)

PRODUCT DIVISION
DAILY PRODUCTION REPORT
TON CONTAINERS EMPTIED

DATE: ______________

JOB ORDER	ITEM	SHIFT	S/N	WT. BEFORE TRANSFER	WT. AFTER TRANSFER	WT. MUSTARD TRANSFER	WT. RESIDUE

ITEM 1

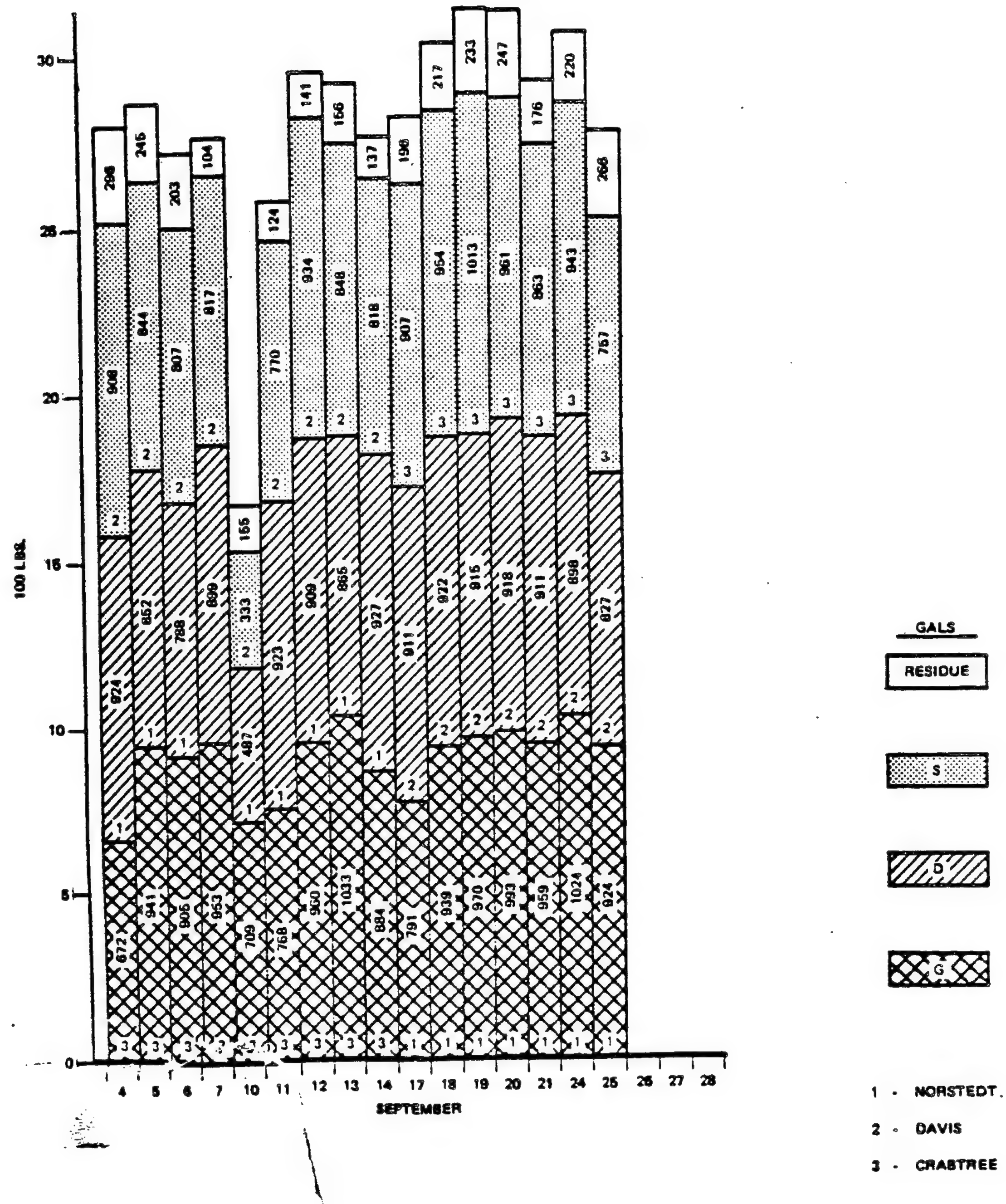
SMURM Form C-[illegible] (1 Sep 72)

T.C. DECONTAMINATION
DAILY PROGRESS REPORT
SUMMARY

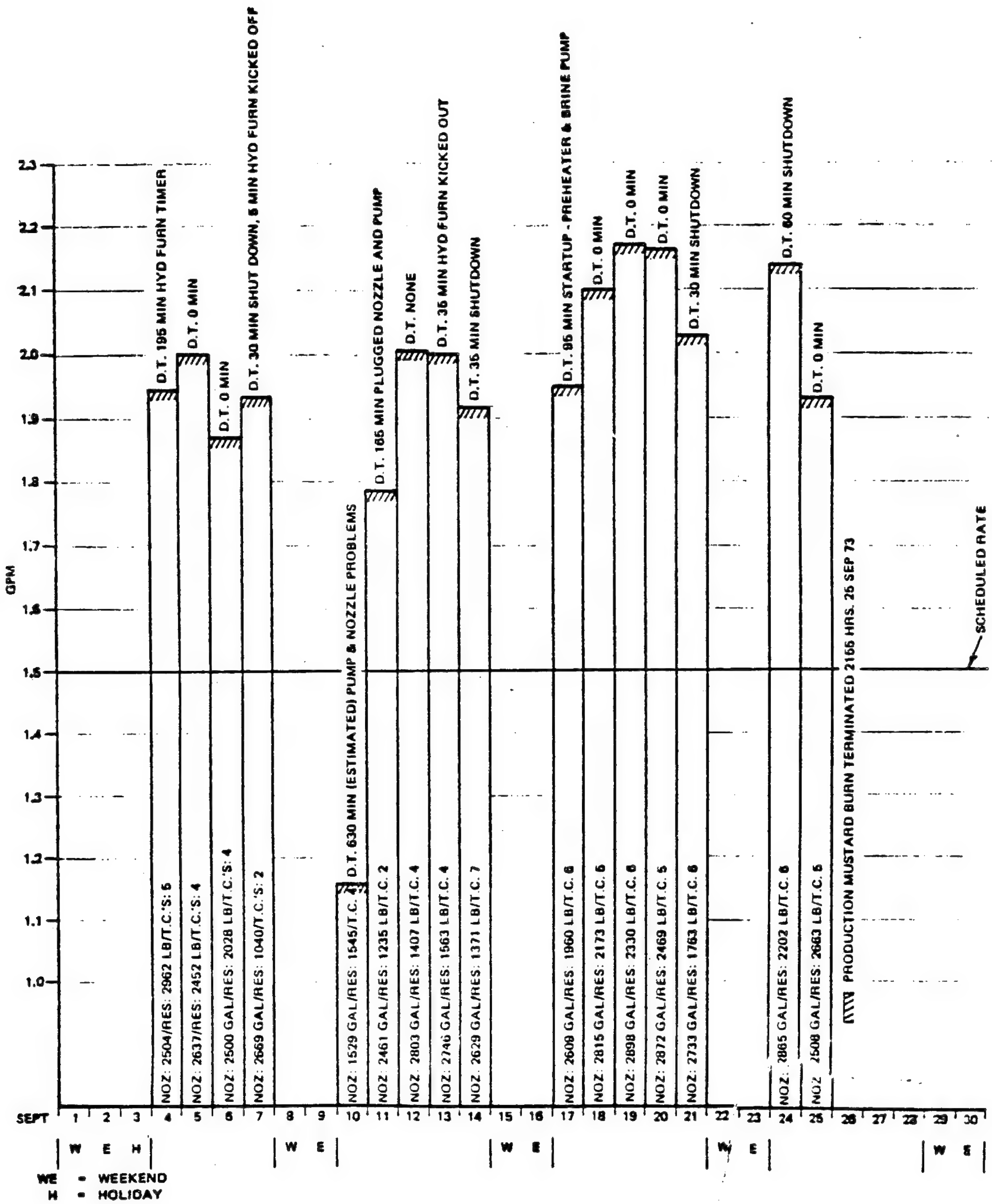
DATE ____________

	EAST FURNACE	WEST FURNACE	TOTAL
POUNDS RESIDUE BURNED			
NUMBER OF (H) TON CONTAINERS BURNED			
NUMBER OF (HD) T.C.'S BURNED			
DOWN TIME			
NO. T.C.'S Cu T			
NO. BARRELS ASH			

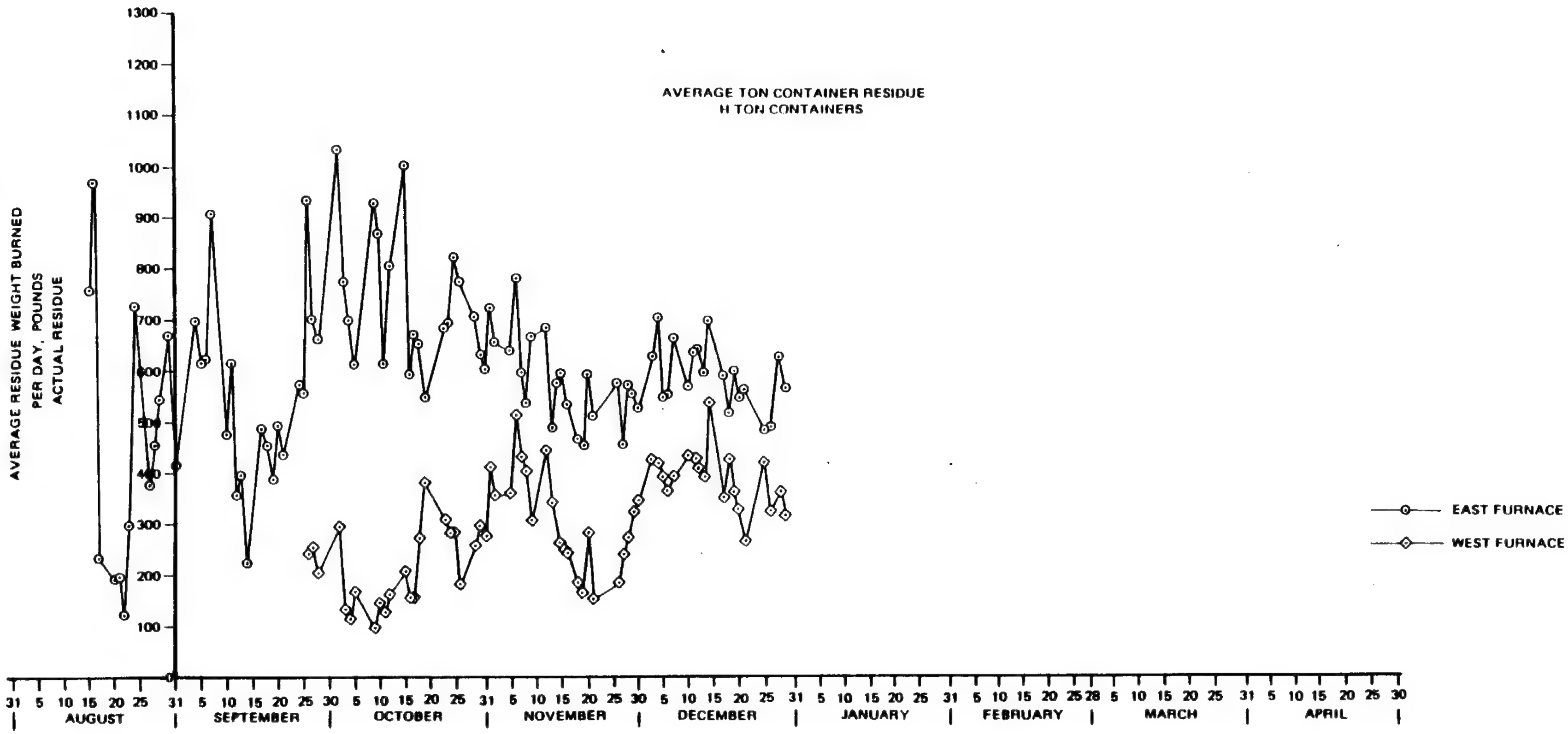
ITEM 2



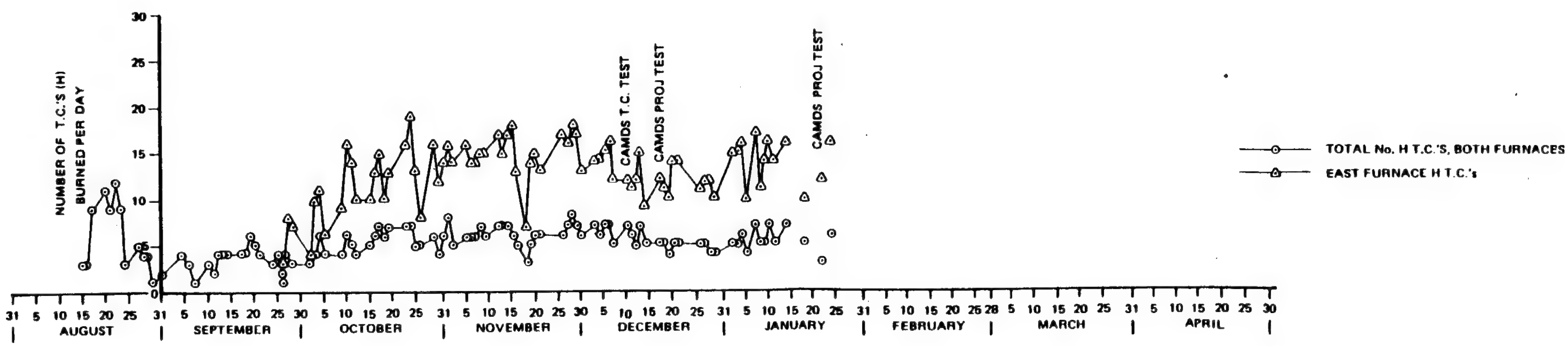
MUSTARD BUR . RATE - BY SHIFT & DAY GALLONS SEPT. 1973
ITEM 4A



MUSTARD BURNED - GPM SEPT. 1973
ITEM 4B

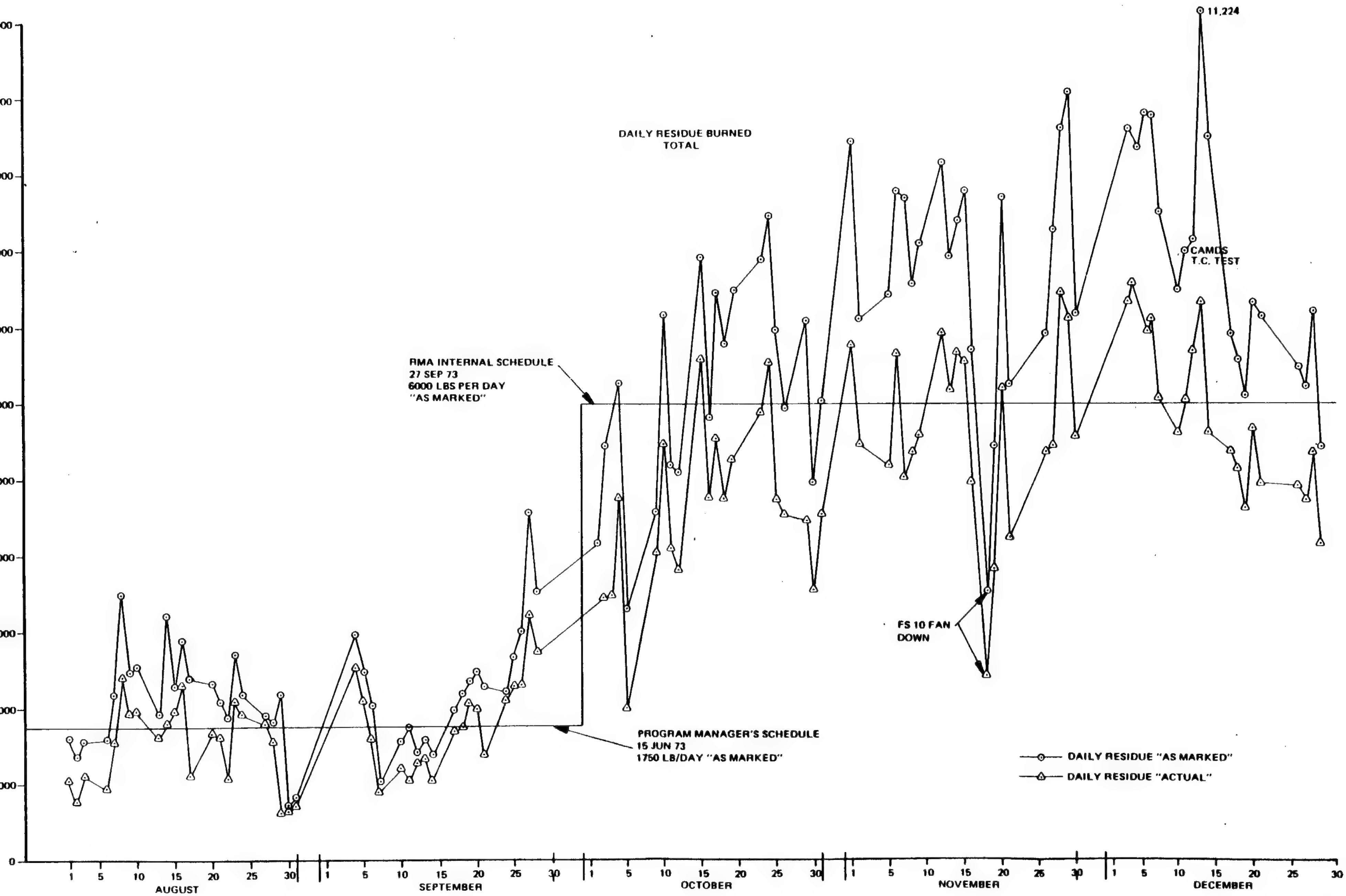


AVERAGE TON CONTAINER RESIDUE
H TON CONTAINERS
AVERAGE RESIDUE WEIGHT BURNED
PER DAY, POUNDS
ACTUAL RESIDUE
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
EAST FURNACE
WEST FURNACE



NUMBER OF T.C.'S (H)
BURNED PER DAY
30
25
20
15
10
5
0
CAMDS T.C. TEST
CAMDS PROJ TEST
CAMDS PROJ TEST
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
TOTAL No. H T.C.'S, BOTH FURNACES
EAST FURNACE H T.C.'s

ITEM 5 & 6



11,224
DAILY RESIDUE BURNED
TOTAL
CAMDS
T.C. TEST
RMA INTERNAL SCHEDULE
27 SEP 73
6000 LBS PER DAY
"AS MARKED"
FS 10 FAN
DOWN
PROGRAM MANAGER'S SCHEDULE
15 JUN 73
1750 LB/DAY "AS MARKED"
DAILY RESIDUE "AS MARKED"
DAILY RESIDUE "ACTUAL"
0
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

ITEM 7 & 8

SARRM-M | Weekly Status Report

Chief Engineer | Dir of Mustard Demil | 25 Feb 74
JBWicks/ds/206

1. Production for the Month:

JO	Week of 13 Feb 74	THRU: 22 Feb 74
5408 Burned Ton Containers	16 ea	123 ea
5410 Cut Ton Containers	29 ea	234 ea
5455 Burned Ton Containers	12 ea	12 ea
5455 Ton Containers Unloaded	20 ea	20 ea
5455 Cut Ton Containers	12 ea	12 ea
5456 Burned Ton Containers	6 ea	6 ea
1401 ST Hyd (Dr)	10920 lbs	10920 lbs
5406 Ton Containers Unloaded	1 ea	1 ea

RESIDUE BURNED	16966 lbs
SALT HAULED	163 dr
MUSTARD BURNED	1139 lbs
MUSTARD UNLOADED	16379 lbs

2. Mustard Demil:

2/18/74

a. There were no operations due to Washington's Birthday holiday.

2/19/74

b. Safety meeting was held at the beginning of the graveyard shift.

c. Switching of the air dryers and checks of the thaw room and tank pit were made daily on each shift during the week.

d. Started burning bulk mustard in the hydrazine furnace at 1415. Discontinued burn from 1600 until 1915 while transferring mustard from the west into the east mustard storage tank.

e. Fired Building 540 dryer on gas at 0330, shut off gas at 0350 due to being unable to get brine to the dryer. Found the control valve stuck due to paint. Valve was freed up, fired up dryer and dried brine from 1100 until 1230 when dryer was shut down due to fan vibration and the system drained.

ITEM 9
Sheet 1 of 5

f. Started drying brine in Building 536 dryer at 1645.

g. Eleven burned residue ton containers were cut and scraped.

h. Four residue ton containers were burned in the east ton container furnace and four residue ton containers in the west ton container furnace. Two burned residue ton containers were reburned.

i. Five hundred fourty five gallons of bulk mustard were burned in the hydrazine furnace.

j. Four drums of salt were filled using the compactor in Building 540.

k. Ninety six drums of salt, twenty drums of ash, and four drums of residue were hauled.

<u>2/20/74</u>

l. Discontinued burning bulk mustard in the hydrazine furnace at 0805.

m. Caustic car DODX 9471 was emptied and washed.

n. Changed gloves in the new unload booth.

o. Started unloading mustard ton containers of the 88 group.

p. Completed burning residue ton containers of the mustard program at 2020 and started burning ton containers of the 88 group in the west ton container furnace.

q. Building 536 dryer was shut down at 0935 and started drying brine again at 1425.

r. There were no burned residue ton containers burned this day.

s. Five residue ton containers were burned in the east ton container furnace and three residue ton containers in the west ton container furnace. One burned residue ton container was reburned. Two of the 88 ton containers were burned in the west ton container furnace.

t. Thirty four drums of salt were filled using the compactor in Building 536.

u. Five hundred ninety four gallons of bulk mustard were burned in the hydrazine furnace.

v. Six of the 88 ton containers were unloaded in the west storage tank.

2/21/74

w. Shut down the east ton container furnace for the balance of the week to make modifications to the furnace for CAMDS tests.

x. Shut down Building 536 dryer from 0010 until 1635.

y. Dried brine in Building 540 dryer from 1220 until 1500 using natural gas. Shut down due to main fan vibration and drained the system.

z. Twelve burned residue ton containers were cut and scraped.

aa. Ten of the 88 ton containers were burned.

*bb. Six of the buried ton containers were burned.

cc. Eight of the 88 ton containers were unloaded.

dd. Sixteen drums of salt were filled using the compactor in Building 540 and fifteen drums filled using the compactor in Building 536.

2/22/74

ee. Shut down the west ton container furnace at 0140 for work on modifications to the east ton container furnace.

ff. Dryer in Building 540 was shut down at 0020, started up at 1045 and shut down at 1500.

gg. Changed gloves in the new unload booth.

hh. Twelve burned residue ton containers of the 88 were cut and scraped.

ii. Six of the burned mustard program ton containers were cut and scraped.

jj. Six of the 83 ton containers were unloaded.

kk. Thirteen drums of salt were filled using the compactor in Building 536.

ll. Mustard Demil personnel performed the following job:

1. Checked and cleaned the new quench tower. Removed approximately one half of a drum.

2. Checked the bottom of the new scrubber.

3. Cleaned the precipitator including the intake duct. Removed one and one half drums.

4. Cleaned both ton container furnaces.

5. Cleaned Building 536 dryer. Removed ten drums of salt.

6. Took brine sample from bottom of new scrubber, from Building 536 brine storage tank and from Building 533 brine storage tank and sent to the laboratory for analysis.

2/23/74

mm. Maintenance performed the following jobs:

1. Continued modifications on the east ton container furnace.

2. Replaced bad sections of pad in the west furnace.

3. Hydrazine:

a. Daily checks of the facility were made.

b. Filled twenty six drums with 10920 pounds of straight hydrazine.

c. Cleaned and prepared fifty five drums for filling.

4. Personnel:

Mustard Demil strength remains at 43 with the following assignments:

Administrative	6
Mustard Demil	36
Loaned	1

SARRM-M (25 Feb 74)
SUBJECT: Weekly Status Report

JOHN A. URSILLO
1LT, ORD
Director
Mustard Demilitarization

CF:
QA
Bldg 522
Product Control

ITEM 9
Sheet 5 of 5

SARRM-M Weekly Status Report

Chief Engineer Dir of Mustard Demil 25 Feb 74
JBWicks/ds/206

1. Production for the Month:

JO	Week of 18 Feb 74	THRU: 22 Feb 74
5408 Burned Ton Containers	16 ea	123 ea
5410 Cut Ton Containers	29 ea	234 ea
5455 Burned Ton Containers	12 ea	12 ea
5455 Ton Containers Unloaded	20 ea	20 ea
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5456 Burned Ton Containers	6 ea	6 ea
1401 ST Hyd (Dr)	10920 lbs	10920 lbs
5406 Ton Containers Unloaded	1 ea	1 ea

RESIDUE BURNED	16966 lbs
SALT HAULED	168 dr
MUSTARD BURNED	1139 lbs
MUSTARD UNLOADED	16879 lbs

2. Mustard Demil:

2/18/74

a. There were no operations due to Washington's Birthday holiday.

2/19/74

b. Safety meeting was held at the beginning of the graveyard shift.

c. Switching of the air dryers and checks of the thaw room and tank pit were made daily on each shift during the week.

d. Started burning bulk mustard in the hydrazine furnace at 1415. Discontinued burn from 1800 until 1915 while transferring mustard from the west into the east mustard storage tank.

e. Fired Building 540 dryer on gas at 0830, shut off gas at 0850 due to being unable to get brine to the dryer. Found the control valve stuck due to paint. Valve was freed up, fired up dryer and dried brine from 1100 until 1230 when dryer was shut down due to fan vibration and the system drained.

f. Started drying brine in Building 536 dryer at 1645.

g. Eleven burned residue ton containers were cut and scraped.

h. Four residue ton containers were burned in the east ton container furnace and four residue ton containers in the west ton container furnace. Two burned residue ton containers were reburned.

i. Five hundred fourty five gallons of bulk mustard were burned in the hydrazine furnace.

j. Four drums of salt were filled using the compactor in Building 540.

k. Ninety six drums of salt, twenty drums of ash, and four drums of residue were hauled.

2/20/74

l. Discontinued burning bulk mustard in the hydrazine furnace at 0805.

m. Caustic car DODX 9471 was emptied and washed.

n. Changed gloves in the new unload booth.

o. Started unloading mustard ton containers of the 88 group.

p. Completed burning residue ton containers of the mustard program at 2020 and started burning ton containers of the 88 group in the west ton container furnace.

q. Building 536 dryer was shut down at 0935 and started drying brine again at 1425.

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u. Five hundred ninety four gallons of bulk mustard were burned in the hydrazine furnace.

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2/21/74

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aa. Ten of the 88 ton containers were burned.

*bb. Six of the buried ton containers were burned.

cc. Eight of the 88 ton containers were unloaded.

dd. Sixteen drums of salt were filled using the compactor in Building 540 and fifteen drums filled using the compactor in Building 536.

2/22/74

ee. Shut down the west ton container furnace at 0140 for work on modifications to the east ton container furnace.

ff. Dryer in Building 540 was shut down at 0020, started up at 1045 and shut down at 1500.

gg. Changed gloves in the new unload booth.

hh. Twelve burned residue ton containers of the 88 were cut and scraped.

ii. Six of the burned mustard program ton containers were cut and scraped.

jj. Six of the M8 ton containers were unloaded.

kk. Thirteen drums of salt were filled using the compactor in Building 536.

ll. Mustard Demil personnel performed the following job:

1. Checked and cleaned the new quench tower. Removed approximately one half of a drum.

2. Checked the bottom of the new scrubber.

3. Cleaned the precipitator including the intake duct. Removed one and one half drums.

4. Cleaned both ton container furnaces.

5. Cleaned Building 536 dryer. Removed ten drums of salt.

* 6. Took brine sample from bottom of new scrubber, from Building 536 brine storage tank and from Building 538 brine storage tank and sent to the laboratory for analysis.

2/23/74

mm. Maintenance performed the following jobs:

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2. Replaced bad sections of pad in the west furnace.

3. Hydrazine:

a. Daily checks of the facility were made.

b. Filled twenty six drums with 10920 pounds of straight hydrazine.

c. Cleaned and prepared fifty five drums for filling.

4. Personnel:

Mustard Demil strength remains at 43 with the following assignments:

Administrative	6
Mustard Demil	36
Loaned	1

SARRH-M (25 Feb 74)
SUBJECT: Weekly Status Report

JOHN A. URSILLO
1LT, ORD
Director
Mustard Demilitarization

CF:
QA
Bldg 522
Product Control

SARRH-M

X THRU Chief Engineer
X TO Supply Division

Sodium Hydroxide Usage for November 1973

Dir of Mustard Demil

13 Dec 73
NEsquibel/ds/206

Mustard Demil Office has calculated from Supply Division inventories the following usage of Sodium Hydroxide, FSN-6810-A85-0009:

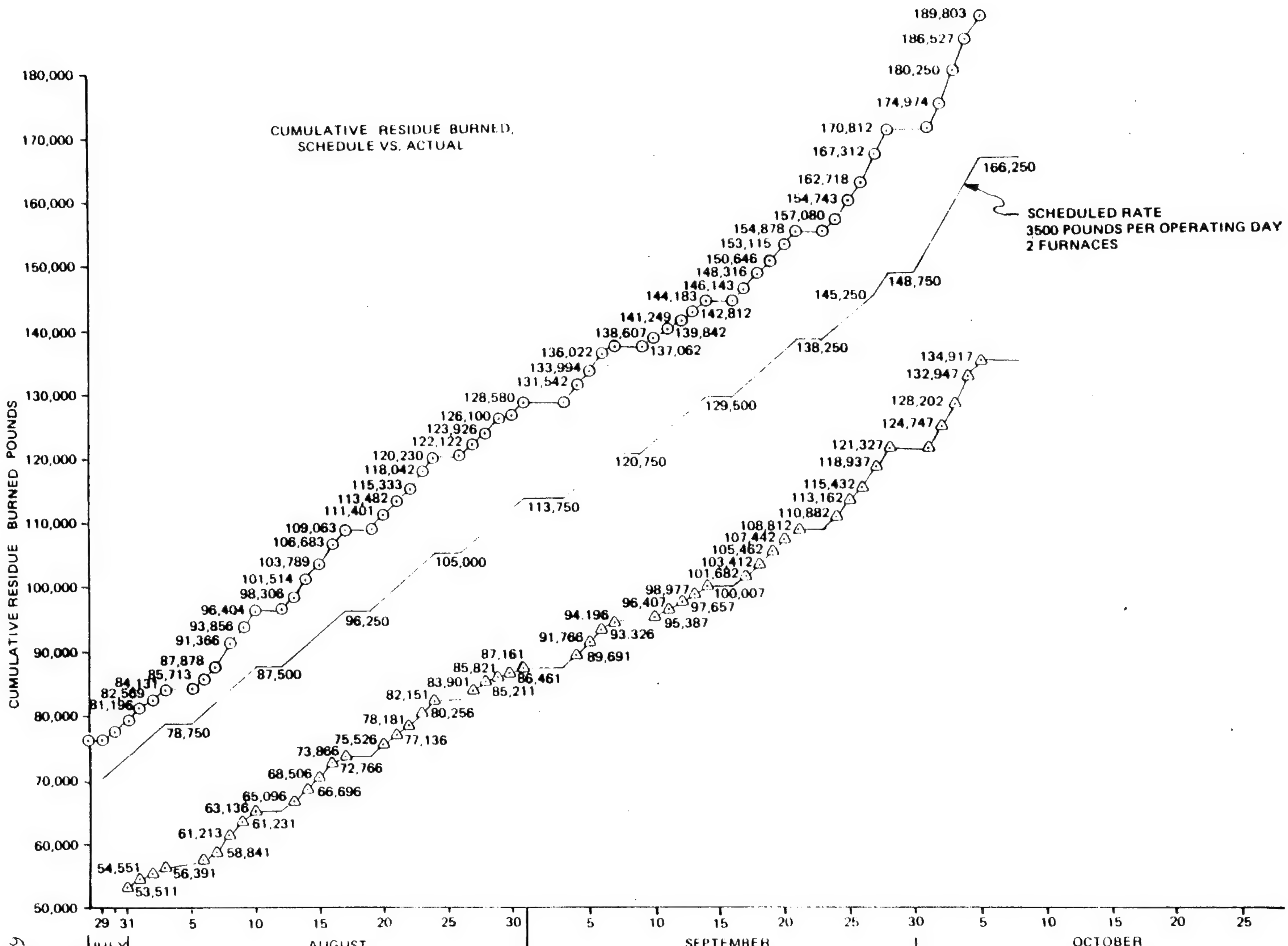
FROM	% CAUSTIC	USED	CHARGE TO
H-Demil Area	50	30.43 ton	JO 76-5411

Jack B Wicks

JACK B. WICKS
Deputy Director
Mustard Demilitarization

CF:
Comptroller

ITEM 11


CUMULATIVE RESIDUE BURNED,
SCHEDULE VS. ACTUAL
CUMULATIVE RESIDUE BURNED POUNDS
SCHEDULED RATE
3500 POUNDS PER OPERATING DAY
2 FURNACES
78,750
87,500
96,250
105,000
113,750
120,750
129,500
138,250
145,250
148,750
166,250
JULY
AUGUST
SEPTEMBER
OCTOBER

ITEM 12

Commander
Gen

DEPARTMENT OF THE ARMY
HEADQUARTERS ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO 80240

SARRM-CE

DATE OF REPORT: 3 October 1973

ROCKY MOUNTAIN ARSENAL DEMILITARIZATION REPORT

REPORT MONTH: September 1973

ITEM/PROGRAM: Mustard Disposal and Air Monitoring Program at Rocky Mountain Arsenal

CHIEF ENGINEER: Mr. Robert K. Hurt   TELEPHONE NUMBER: 6270/457

PROJECT OFFICERS: 2LT David Sageman, Bulk Mustard Program
1LT James Christie, Air Monitoring Program

REPORT CONTROL SYMBOL: SMUSM-131

1. Mustard Disposal Program

a. Overall Program Status:

(1) The bulk burning of mustard agent (phase II) was completed on 25 September 1973, in a highly successful manner and two months ahead of the planned schedule. A total of 511,540 gallons of mustard agent had been incinerated at the end of the month. This included both the mustard burned through the nozzles, and that burned as residue in the emptied ton containers. The total number of ton containers burned at the end of September amounted to 2,019 containers; this does not include the ton containers which were added into the program during the original test operations, and which have also been burned.

(2) During the month of September, there was a total of 41,778 gallons of mustard burned through the nozzles, and 4,224 gallons of residue, for an overall total of 46,002 gallons of agent burned during the period. The bulk burn was completed at 2155 hours, 25 September 1973, and the hydrazine furnace shut down at that time.

(3) Prior to the shut down, the hydrazine furnace operated for 94% of the available time during September, with the mustard feed system presenting the major down time during the month. It was necessary to replace the centrifugal mustard feed pump on 10 September * with approximately 13 hours of down time.

(4) The following tabulation shows a breakout of the down time experienced during the month of September. It may be noted that there

was less than 22 hours down time experienced during the month.

DOWNTIME TABULATION

	Minutes	Hours	Percentage
Start Up (Weekly)	215	3.6	16.4
Furnace Controls	235	3.9	17.9
Mustard Feed System	765	12.7	58.4
Shut Down (Weekly)	95	1.6	7.3
TOTAL	1,310	21.8	100.0

(5) During September, up to the time the bulk burn was completed, the burning rate averaged 1.82 gallons per minute of available time (1,440 minutes per day), including all down time. The burning rate during the actual operating time amounted to 1.96 gallons per minute.

(6) During the month a total of 106 ton containers were burned, averaging approximately 6 containers per day. The average weight of residue burned in the ton containers amounted to approximately 400 pounds per container. The west furnace was rebricked during September and the punch repaired. A new container support pedestal was installed, and after proper curing the second furnace was placed in operation during the 4-12 shift on 26 September 1973.

(7) A total of 34 ton containers have been held in reserve to furnish mustard agent for the new scrubber system test run and for "CAMDES" experimental runs. These containers include 16 containers of distilled mustard and 18 containers of Levenstein Mustard.

(8) At the close of the month there was a total of 1,388 ton containers yet to be burned, including the 34 containers mentioned in paragraph (7) above. It is estimated that the average weight of these containers will amount to 600 pounds per container.

b. Past Month Milestones of Key Events:

(1) Spray Dryer

The spray dryer continued to operate without a major down time, however, the stack emission is still above State standards.

(2) New Scrubber/Quench System

(a) Work continued on the new scrubber/quench system, and due to a slippage by the contractor on the scrubber fabrication, the installation completion will be delayed until mid-October.

(b) The test plan submitted for the new scrubber/quench system was approved during September.

c. Next Month's Milestones of Key Events:

(1) Work will continue on the scrubber/quench tank system with completion scheduled during the week of 15 October. Testing will be conducted using both distilled mustard and Levenstein Mustard, along with the burning of empty containers having varied amounts of residue.

(2) Installation of a high energy venturi scrubber is to be completed during October or November, in the spray drier system, to resolve the opacity problem in the stack emission.

(3) A final schedule will be established in the third phase of the mustard demilitarization program as soon as the new scrubber system is available and tested, and the optimum burning conditions are determined in the two ton container furnaces.

2. Air Monitoring Program

a. The air monitoring network has undergone an extensive review by the Army Environmental Hygiene Agency (AEHA). The preliminary AEHA comments/recommendations have been received at Rocky Mountain Arsenal. This Arsenal is currently installing the new air conditioners to achieve the necessary temperature control.

b. The "Mast" ozone meters are to be further studied by AEHA. Rocky Mountain Arsenal must either procure new "Mast" ozone instruments or the instruments currently in storage at Tooele Army Depot must be transferred to us as soon as possible.

c. The monitoring to be performed to support the M-34 Demilitarization program is currently being further evaluated.

Robert K. Hurt
ROBERT K. HURT
Chief Engineer

ITEM 14
Sheet 3 of 4

SARRM-CE DATE OF REPORT: 3 October 1973
ROCKY MOUNTAIN ARSENAL DEMILITARIZATION REPORT

<u>DISTRIBUTION:</u>

Program Mgr for Demil
of Chemical Material,
US Army Materiel Command (quad)
Cdr, Edgewood Arsenal,
Attn: SAREA-DM (dupe)
<u>ROCKY MOUNTAIN ARSENAL</u>
Commander
Dir of Mustard Demilitarization
Director of Facilities
Director of Logistical Services
Chief, Quality Assurance Office
Chief, Safety Office
Post Surgeon
Comptroller

ITEM 14
Sheet 4 of 4

REQUEST FOR AND RESULTS OF TESTS	PAGE NO.	NO. OF PAGES

SECTION A - REQUEST FOR TEST

1. TO: (Include ZIP Code)	2. FROM: (Include ZIP Code)
Quality Assurance Office Quality & Environmental Assurance Div Bldg. 313	Directorate Mustard Demil Mustard Demil Operations Bldg. 111
3. PRIME CONTRACTOR AND ADDRESS (Include ZIP Code) CONTRACT NUMBER	4. MANUFACTURING PLANT NAME AND ADDRESS (Include ZIP Code) P. O. NUMBER

5. END ITEM AND/OR PROJECT	6. SAMPLE NUMBER	7. LOT NO	8. REASON FOR SUBMITTAL	9. DATE SUBMITTED
Mustard Demil			Analysis	31 Jan 74

10. MATERIAL TO BE TESTED	10a. QUANTITY SUBMITTED	11. QUANTITY REPRESENTED	12. SPEC. & AMEND AND/OR DRAWING NO. & REV FOR SAMPLE & DATE
See attached			

13. PURCHASED FROM OR SOURCE	14. SHIPMENT METHOD	15. DATE SAMPLED AND SUBMITTED BY
See attached		LT URSILLO 31 Jan 74 Dir Mustard Demil

16. REMARKS AND/OR SPECIAL INSTRUCTIONS AND/OR WAIVERS.

See attached

17. SEND REPORT OF TEST TO

Dir Mustard Demil, LT Ursillo, Bldg. 111; QAO Insp, Mr. Cook, Bldg 111; Bldg 537 Inspection, Dr. Gaon, Bldg 1710

SECTION B - RESULTS OF TEST *(Continue on plain white paper if more space is required)*

1. DATE SAMPLE RECEIVED	2. DATE RESULTS REPORTED	3. LAB REPORT NUMBER
31 Jan 74	1 Feb 74	See attached

4. TEST PERFORMED	RESULTS OF TEST	SAMPLE RESULT	REQUIREMENTS
See attached			

DATE	TYPED NAME AND TITLE OF PERSON CONDUCTING TEST	SIGNATURE
1 Feb 74	EDDIE R. JONES Ch, QEAD, QAO	Eddie R Jones

DD FORM 1 FEB 62 1222 REPLACES DD FORM 1222, WHICH IS OBSOLETE

ITEM 19
Sheet 1 of 2

6-65

Item 4, Test Results (Mustard Demil)

Bldg 538, Scrubber Brine

Date	Sample Lab. Nos.	Sample Number	Time	Specific Gravity	H Content ug/M1	pH
31 Jan 94	63923	1	0030	1.18	<0.25	12.2
	63964	2	0130	1.17	<0.25	12.3
	63967	3	0230	1.15	<0.25	12.1
	63973	4	0330	1.14	<0.25	12.2
	63978	5	0430	1.16	<0.25	12.1
	63979	6	0530	1.16	<0.25	12.1
	63987	7	0630	1.17	<0.25	12.2
	63989	8	0730	1.17	<0.25	12.2
	63991	1	0830	1.17	<0.25	10.3
	63997	2	0930	1.18	<0.25	12.2
	63999	3	1030	1.18	<0.25	12.0
	64005	4	1130	1.18	<0.25	11.9
	64007	5	1230	1.19	<0.25	12.2
	64019	6	1330	1.19	<0.25	12.4
	64020	7	1430	1.19	<0.25	12.5
	64021	8	1530	1.19	<0.25	12.3
	64022	1	1630	1.19	<0.75	10.7
	64027	2	1730	1.19	<0.75	11.9
	64028	3	1830	1.18	<0.75	11.4
	64033	4	1930	1.19	<0.75	11.4
	64034	5	2030	1.19	<0.75	10.2
	64041	6	2130	1.19	<0.75	9.9
	64051	7	2230	1.20	<0.75	10.6
	64052	8	2330	1.20	<0.75	10.7

REMARKS:

SMURM Form Q-30 (29 Sep 72)

ITEM 19
Sheet 2 of 2

EFFECTIVE: 1 April 1973 thru 14 April 1973

CHIEF, PRODUCT DIVISION
ARNE G. SANDBERG

PRODUCTION CONTROLLER
NASH ESQUIBEL

GENERAL FOREMAN
DONALD R. PLANT

ENGINEER
JACK B. WICKS

OFFICE - BLDG 111
MARILYN JOHNSON

OFFICE - BLDG 522
AUGUSTINE M. TRUJILLO

GVYD: 2400-0830 Hours

ENGINEER: NORSTEDT, Carl
FOREMEN: CANDELARIE, Ancelmo
KIRWIN, Cliff
LEADERS: MERKLIN, Wilbur
NELSON, Richard
WILLIAMS, Keith

1. CONNERS, Dale
2. GALLEGOS, Ben
3. GLUCK, Monte
4. JARAMILLO, Sidney
5. JONES, Joseph
6. JONLAND, Spencer
7. LOVATO, John
8. ORTH, Ken
9. PATE, Willie J.
10. ROMERO, John
11. SENA, Fred
12. SMITH, G. B.
13. STUART, William
14. VIGIL, Nick

SWING: 1600-0030 Hours

ENGINEER: CRABTREE, S.
FOREMEN: MOTOOKA, Ute Y.
SCHERBARTH, Robert
LEADERS: FUENTEZ, Alex
LOVETT, Sam
LYNCH, Harvey

1. ACOSTA, Manuel
2. BERNAL, John
3. CRUZ, Joseph M.
4. FISHER, Donald
5. LA COMBE, Bert
6. LUEKENGA, Frank
7. MARTINEZ, J. M.
8. MULLINS, James
9. QUINTANA, Ray
10. RUTHVEN, Marty
11. SANDOVAL, Juan F.
12. SMITH, Lester W.
13. TRUJILLO, Albert

DAYS: 0800-1630 Hours

ENGINEER: DAVIS, Doyle
FOREMEN: DOUGLASS, Jesse
GARCIA, Ray
LEADERS: LEHL, Daniel
SMITH, Bracy
SPENCER, Nathan

1. DAVIS, Fred
2. HANKS, Steven
3. JAMES, Darl L.
4. KENTNER, Ray
5. LYONS, William
6. MACIAS, Martin
7. MACIAS, Richard
8. MASCARENAS, Joe
9. PADILLA, Abran
10. STUART, Sam Jr.
11. THOMPSON, James
12. TNIKLEPAUGH, George
13. TRUJILLO, Ben
14. VON AHN, George

M34 DEMIL: DAYS ONLY, 0730-1600

ENGINEER: JACOBS, R. A.
FOREMEN: MILLER, Ray
NOVOTNY, Frank

1. DONAGHE, Leo
2. CANTONWINE, David
3. GARCIA, Arthur
4. KUITEMS, John
5. THOMPSON, A. K.

ITEM 20

MUSTARD PUNCH LIST
Week Ending 30 Dec 72

SMURM-O-P

Director of Facilities | Chief, Product Division | 27 Dec 72
ECZeorian/mj/206

1. Replace the gate valve on the mustard transfer line and the gate valve on the suction line of the moyno pump (one above the floor with plug, cock-type valve.

2. Remove pressure regulator on moyno pump and blank tank and line openings.

3. Replace moyno rotor and stator with new units and repack pump.

4. Repair flow control valve on caustic addition piping to quench tank. (Valve leaks through and will not shut off.)

5. Replace unloading and vent hoses in north and south unloading booths.

6. Clean bottom insulators in precipitator.

7. Repair condensate or steam leaks in north thaw room heater.

8. Repair vent fan in hood of West furnace.

9. Balance scrubber exhaust fan.

10. Install mustard piping, nozzles and controls in East furnace to burn mustard in East furnace at the same time as burning mustard in the West furnace.

11. Install lights in back of furnace.

12. Replace plexiglass windows on unload booth that are broken.

13. Repair and replace west Homomixer.

14. Continue work on Building 538 scrubber area housing.

15. Install coil in overhead heater, south wall of Building 537.

16. Close down opening through the back of the East furnace at the upper view glass to the same size as the exposed view glass area and clean glasses.

17. Insulate both punches from furnace by installation of an insulated aluminum sheet.

ITEM 21 (Sheet 1 of 2)

SMURM-O-P (27 Dec 72)
SUBJECT: MUSTARD PUNCH LIST (Week Ending 30 Dec 72)

18. Repair West furnace punch so it will operate properly.

19. Replace grating along east wall of tank pit with deck plate.

20. Fabricate a complete set of spare nozzles for quench tank and duct.

21. Install pressure gage on gas line to East and West furnace. Place gage in plug where lower burner was removed. Gage to read in inches of water - zero to approximately 30 inches. Complete prior to start-up on Friday, 29 December.

22. Install new valves on sample line at scrubber pump. Complete prior to start-up on Friday, 29 December.

ELMER C. ZEORIAN
Chief, Product Division

CF:
Dir of Ind Ops (2)
Shift Engineers (1)
Maintenance Div (4)

ITEM 21 (Sheet 2 of 2)

CODE 8049

MACHINE DATA

AUXILIARY OIL PUMP TO HYDROZENE FURNACE

Building 538-Adjacent to Hydrozene Furnace

SUPPLIER NAME AND ADDRESS

Aurora Pump Company, Aurora, Illinois

PURCHASED: NEW [ ] USED [X]

MODEL	TYPE	SERIAL NO.	PROPERTY	GOVT. IDENT. NO.
		15T-C307746-AI		06-09-005664

DATE PURCHASED	P.O. NO.	DATE REC'D	WEIGHT	DATE INSTALLED

FEEDER TYPE AND SIZE	TYPE SWITCH	FUSE SIZE	TOTAL AMPS	CLASS	CODE

LOCATION	DATE	BUILDING	DEPARTMENT	LOCATION
INSTALLED				
MOVED				
MOVED				

COST	
PURCHASE COST	
FREIGHT	
INSTAL. MAT'L	
" LABOR & BUR.	
TOTAL	

MOTORS

NAME	RPM	TYPE	VOLTAGE	AMPS	CYCLE	PHASE	H.P.	FRAME NO.	SERIAL NO.	OVERLOAD HEATER SIZE
G.E.	1730		220/440	13.9/	60	3	5		JX1746	
				6.95						
	Nine lead motor									
	Parallel-series star connection									
	Government prop. No-06-09-004384									

ACCESSORIES

ITEM	DESCRIPTION	PROP. NO.
Oval	by Brooks Instrument Division of Emerson Electric Company	
Gear	scale - 0 to 10 GPM - rate of flow	
Meter	totalizer to 1,000,000 gal.	
	meter no.-9455AA7BA3A	
	access no.-9255A7B2B141	
	serial no.-7103-56455/3	
Air	by A. W. Cash Company, type 1164, serial no.- 75162	
Relief	Range - 40 to 60	
Valve		

ITEM 22 (Sheet 1 of 2)

PL 97487 B

PREVENTIVE MAINTENANCE WORK ORDER

CODE 8049

ITEM	PROPERTY NO.	DATE ISSUED
Auxiliary Oil Pump to Hydrozene Furnace		10 May 73

SERIAL NO.	DEPARTMENT	LOCATION	DATE COMPLETED
	Bldg. 538	Adjacent to Hydrozene Furnace	

FREQ. CODE: 1 ANNUAL, 2 SEMI-ANNUAL, 4 QUARTERLY, 6 BI-MONTHLY, 12 MONTHLY, 26 SEMI-MONTHLY

NOTE: DO ENCIRCLED OPERATION NUMBERS ONLY

OPER. NO.	FREQ. CODE	PREVENTIVE MAINTENANCE OPERATION	✓ - OK X - SEE NOTE	STANDARD
		Safety Note-Personnel will wear congo-red treated coveralls, safety shoes, cotton socks and underwear, protective mask in slung position and hard hat.		
1	2	Lubricate grease fittings; outboard of packing gland opp. drive side on pump and on drive end of motor. Use lithium based #2 grease. Wipe off excess lubricant.		.08
2	6	Lubricate oil ports; on pump at end opposite drive outboard of packing gland, same end inboard of packing gland; at same points on drive side and at packing gland both sides of pump housing. Use SAE 20w. non-detergent oil. Wipe off excess.		.07
3	6	Take up equally on packing glands, from 1/8 to 1/4 turn normally but if packing is loose, take up till snug.		.03
4	6	Observe unit and associated piping for leaks and excessive vibration. Check coupling and mounts. Report any derect.		.02
5	*	Repack pump glands.		
		* Every two years if pump is used regularly or more frequently as required in even numbered years.		.67

ITEM 22 (Sheet 2 of 2)

PREV. MAINT. SCHEDULE	WK.
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PHASE I DATE	PHASE I GALLONS OF AGENT DESTROYED	PHASE II DATE	PHASE II GALLONS OF AGENT DESTROYED	PHASE III DATE	PHASE III GALLONS OF AGENT DESTROYED
25 Oct 72*	98,738	6 Jun 73	306,132	3 Oct 73	512,434
1 Nov	109,516	13 Jun	318,901	10 Oct	514,605
8 Nov	110,513	20 Jun	332,739	17 Oct	
15 Nov	111,922	27 Jun	346,852	24 Oct	520,678
22 Nov	117,061	4 Jul	356,429	31 Oct	523,636
29 Nov		11 Jul	370,472	7 Nov	527,816
6 Dec	124,539	18 Jul	384,506	14 Nov	532,430
13 Dec	128,895	25 Jul	395,931	21 Nov	536,759
20 Dec	136,106	1 Aug	408,113	28 Nov	
27 Dec		8 Aug	418,734	5 Dec	543,855
3 Jan 73	144,400	15 Aug	432,387	12 Dec	
10 Jan	149,973	22 Aug	446,361	19 Dec	551,694
17 Jan	154,260	29 Aug	460,842	26 Dec	553,789
24 Jan	157,237	5 Sep		2 Jan 74	556,225
31 Jan	164,019	12 Sep	483,909	9 Jan	560,919
7 Feb	170,329	19 Sep	498,545	16 Jan	564,733
14 Feb	177,974	27 Sep	510,730	23 Jan	568,875
21 Feb				30 Jan	
28 Feb	191,019			6 Feb	574,684
7 Mar	198,497			13 Feb	578,061
14 Mar	204,967			20 Feb	582,263
21 Mar	211,618			CAMDS Containers	584,243
28 Mar	221,656				
4 Apr	227,835				
11 Apr	234,173				
18 Apr	242,369				
25 Apr	253,046				
2 May	263,172				
9 May	266,780				
16 May	277,517				
23 May	288,296				
30 May	293,181				

NOTE: This cumulative total includes bulk agent plus ton container residue.
*Start of requirement for weekly message report.

Table 6–3. WEEKLY CUMULATIVE TOTAL OF AGENT DESTROYED AS REPORTED BY MESSAGE TO PROGRAM MANAGER
(As Shown on Figure 6–1)

OPERATING PERIOD	DAYS	BULK AGENT INCINERATED pounds	BULK AGENT INCINERATED gallons	TOTAL AVAILABLE OPERATING TIME minutes	TOTAL DOWN-TIME minutes	TOTAL ACTUAL OPERATING TIME minutes	OVERALL GPM THROUGH NOZZLE gal/min	EFFECTIVE GPM THROUGH NOZZLE gal/min
21 - 25 Aug 72	5							
28 - 31	4							
Aug Totals	9	Incomplete	—	12,510	1,830	10,680		
1 - 8 Sep 72	5	47,990						
11 - 15	5	47,380						
18 - 22	0	0						
25 - 29	5	37,300						
Sep Totals	15	132,670	13,267	22,915	12,340	10,575	0.58	1.25
2 - 6 Oct 72	5	26,550						
10 - 13	4	22,300						
16 - 20	5	39,940						
24 - 27	4	41,400						
30 - 31	2	15,730						
Oct Totals	20	145,920	14,592	30,240	5,980	24,260	0.48	0.60
1 - 3 Nov 72	3	11,530						
6 - 10	5	0						
13 - 17	5	17,510						
19 - 22	4	34,230						
27 - 30	4	28,260						
Nov Totals	21	91,530	9,153	30,240	14,185	16,055	0.30	0.57
1 Dec 72	1	10,580						
4 - 8	5	29,310						
11 - 15	5	44,650						
18 - 22	5	55,320						
26 - 29	3	32,010						
Dec Totals	19	171,870	17,187	27,360	4,560	22,800	0.63	0.75

Table 6—4. MUSTARD DEMILITARIZATION PROGRAM BULK AGENT INCINERATION DATA
(Sheet 1 of 3)

OPERATING PERIOD	DAYS	BULK AGENT INCINERATED pounds	BULK AGENT INCINERATED gallons	TOTAL AVAILABLE OPERATING TIME minutes	TOTAL DOWN-TIME minutes	TOTAL ACTUAL OPERATING TIME minutes	OVERALL GPM THROUGH NOZZLE gal/min	EFFECTIVE GPM THROUGH NOZZLE gal/min
2 - 5 Jan 73	4	31,700						
8 - 12	5	47,880						
15 - 19	5	39,440						
22 - 26	5	38,480						
29 - 31	3	37,720						
Jan Totals	22	195,220	19,522	31,680	8,200	23,480	0.62	0.83
1 - 2 Feb 73	2	21,770						
5 - 9	5	64,080						
12 - 16	5	67,710						
20 - 23	4	53,550						
26 - 28	3	41,600						
Feb Totals	19	248,710	24,871	27,360	2,250	25,110	0.91	0.99
1 - 2 Mar 73	2	28,660						
5 - 9	5	60,080						
12 - 16	5	61,050						
19 - 23	5	71,210						
26 - 30	5	96,210						
Mar Totals	22	317,210	31,721	31,680	3,469	28,211	1.00	1.12
2 - 6 Apr 73	5	41,840						
9 - 13	5	66,510						
16 - 20	5	87,230						
23 - 27	5	97,920						
30	1	18,250						
Apr Totals	21	311,750	31,175	30,240	6,318	23,922	1.03	1.30
1 - 4 May 73	4	49,770						
7 - 11	5	51,540						
14 - 18	5	115,950						
21 - 25	5	51,380						
29 - 31	3	70,170						
May Totals	22	338,810	33,881	31,680	7,870	23,810	1.07	1.42

Table 6—4. MUSTARD DEMILITARIZATION PROGRAM BULK AGENT INCINERATION DATA
(Sheet 2 of 3)

OPERATING PERIOD	DAYS	BULK AGENT INCINERATED pounds	BULK AGENT INCINERATED gallons	TOTAL AVAILABLE OPERATING TIME minutes	TOTAL DOWN-TIME minutes	TOTAL ACTUAL OPERATING TIME minutes	OVERALL GPM THROUGH NOZZLE gal/min	EFFECTIVE GPM THROUGH NOZZLE gal/min
1 Jun 73	1	23,980						
4 - 8	5	123,111						
11 - 15	5	120,440						
18 - 22	5	137,460						
25 - 29	5	109,460						
Jun Totals	21	514,451	51,445	30,240	2,960	27,280	1.70	1.89
2 - 6 Jul 73	4	112,840						
9 - 13	5	121,600						
16 - 20	5	122,500						
23 - 27	5	102,280						
30 - 31	2	4,919						
Jul Totals	21	464,139	46,414	30,240	2,890	27,350	1.53	1.70
1 - 3 Aug 73	3	59,350						
6 - 10	5	100,220						
13 - 17	5	125,260						
20 - 24	5	139,040						
27 - 31	5	121,970						
Aug Totals	23	545,840	54,584	33,120	2,955	30,165	1.65	1.81
4 - 7 Sep 73	4	103,100						
10 - 14	5	121,600						
17 - 21	5	139,270						
24 - 25	2	53,730						
26 - 28	0	—						
Sep Totals	16	417,700	41,770	22,915	1,250	21,665	1.82	1.93
7 - 11 Jan 74		2,009						
14 - 18		390						
Jan Totals		2,399	240	Non-scheduled				
19 - 22 Feb 74		11,390						
Feb Totals		11,390	1,139	Non-scheduled				

Table 6-4. MUSTARD DEMILITARIZATION PROGRAM BULK AGENT INCINERATION DATA
(Sheet 3 of 3)

OPERATING PERIOD	OPERATING DAYS	TON CONTAINERS INCINERATED East Furnace	West Furnace	Total	RESIDUE BURNED, POUNDS East Furnace	West Furnace	Total	AVERAGE T.C.'S BURNED PER OPERATING DAY East Furnace	West Furnace	Total	AVERAGE RESIDUE BURNED PER T.C. East Furnace	West Furnace	Total	T.C.'S CUT	DRUMS ASH
21 - 25 Aug 72	5	28	28		No Data										
28 - 31 Aug	4	4	4	3,190			1.0			798					
Aug Totals	9	32	32		Incomplete		3.6								
1 Sep 72	1	4	4	535			4.0			134					
4 - 8 Sep	4	25	25	9,201			6.3			368					
11 - 15 Sep	5	29	29	10,592			5.8			365					
18 - 22 Sep	0	0	0	0			0			0					
25 - 29 Sep	5	25	25	9,932			5.0			397					
Sep Totals	15	83	83	30,260			5.5			366					
2 - 6 Oct 72	5	20	20	8,495			4.0			425					
10 - 13 Oct	4	17	17	5,014			4.3			295					
16 - 20 Oct	5	24	24	8,836			4.8			368					
24 - 27 Oct	4	5	5	541			1.3			108					
30 & 31 Oct	2	12	12	3,446			6.0			287					
Oct Totals	20	78	78	26,332			3.9			338					
1 - 3 Nov 72	3	11	11	3,286			3.7			299					
6 - 10 Nov	0	0	0	0			0			0					
13 - 17 Nov	5	41	41	7,715			8.2			188					
19 - 22 Nov	4	31	31	6,014			7.8			194					
27 - 30 Nov	4	29	29	10,935			7.3			377					
Nov Totals	16	112	112	27,950			7.0			250					
1 Dec 72	1	0	0	0			0			0					
4 - 8 Dec	5	27	27	11,224			5.4			416					
11 - 15 Dec	5	29	29	10,405			5.8			359					
18 - 22 Dec	5	30	30	12,074			6.0			402					
26 - 29 Dec	3	19	19	6,161			6.3			324					
Dec Totals	19	105	105	39,864			5.5			380					

TABLE 6–5 MUSTARD DEMILITARIZATION PROGRAM TON CONTAINER INCINERATION DATA (Sheet 1 of 4)

OPERATING PERIOD	OPERATING DAYS	TON CONTAINERS INCINERATED			RESIDUE BURNED, POUNDS			AVERAGE T.C.'S BURNED PER OPERATING DAY			AVERAGE RESIDUE BURNED PER T.C.			T.C.'S CUT	DRUMS ASH
		East Furnace	West Furnace	Total	East Furnace	West Furnace	Total	East Furnace	West Furnace	Total	East Furnace	West Furnace	Total		
2 - 5 Jan 73	4	26	26	6,672			6.5			257					
8 - 12 Jan	5	35	35	10,130			7.0			289					
15 - 19 Jan	5	0	0	0			0			0					
22 - 26 Jan	5	17	17	1,907			3.4			112					
29 - 31 Jan	3	16	16	1,288			5.3			81					
Jan Totals	22	94	94	19,997			4.3			212					
1 & 2 Feb 73	2	11	11	1,205			5.5			110					
5 - 9 Feb	5	32	32	3,974			6.4			124					
12 - 16 Feb	5	40	40	5,829			8.0			146					
20 - 23 Feb	4	42	42	5,343			10.5			127					
26 - 28 Feb	3	39	39	5,829			13.0			149					
Feb Totals	19	164	164	22,180			8.6			135					
1 & 2 Mar 73	2	28	28	3,273			14.0			117					
5 - 9 Mar	5	64	64	5,059			12.8			79					
12 - 16 Mar	5	57	57	7,052			11.4			124					
19 - 23 Mar	5	46	46	5,960			9.2			130					
26 - 30 Mar	5	49	49	5,555			9.8			113					
Mar Totals	22	244	244	26,899			11.1			110					
2 - 6 Apr 73	5	14	14	1,532			2.8			109					
9 - 13 Apr	5	48	48	7,779			9.6			162					
16 - 20 Apr	5	46	46	7,190			9.2			156					
23 - 27 Apr	5	40	40	5,529			8.0			138					
30 Apr	1	9	9	1,543			9.0			171					
Apr Totals	21	157	157	23,573			7.5			150					
1 - 4 May 73	4	15	15	2,047			3.4			136					
7 - 11 May	5	22	22	3,274			4.4			149					
14 - 18 May	5	29	29	5,040			5.8			174					
21 - 25 May	5	25	25	3,042			5.0			122					
29 - 31 May	3	31	31	4,218			10.3			136					
May Totals	22	122	122	17,621			6.1			144					

TABLE 6–5 MUSTARD DEMILITARIZATION PROGRAM TON CONTAINER INCINERATION DATA (Sheet 2 of 4)

OPERATING PERIOD	OPERATING DAYS	TON CONTAINERS INCINERATED East Furn	TON CONTAINERS INCINERATED West Furn	TON CONTAINERS INCINERATED Total	RESIDUE BURNED, POUNDS East Furn	RESIDUE BURNED, POUNDS West Furn	RESIDUE BURNED, POUNDS Total	AVERAGE T.C.'S BURNED PER OPERATING DAY East Furn	AVERAGE T.C.'S BURNED PER OPERATING DAY West Furn	AVERAGE T.C.'S BURNED PER OPERATING DAY Total	AVERAGE RESIDUE BURNED PER T.C. East Furn	AVERAGE RESIDUE BURNED PER T.C. West Furn	AVERAGE RESIDUE BURNED PER T.C. Total	T.C.'S CUT	DRUMS ASH
1 Jun 73	1	8		8	1,102			8.0			138				
4 - 8 Jun	5	38		38	5,497			7.6			145				
11 - 15 Jun	5	41		41	7,665			8.2			187				
18 - 22 Jun	5	53		53	11,215			10.6			212				
25 - 29 Jun	5	55		55	8,602			11.0			156				
Jun Totals	21	195		195	34,801			9.3			175				
2 - 6 Jul 73	4	50		50	8,781			12.5			176				
9 - 13 Jul	5	62		62	11,081			12.4			179				
16 - 20 Jul	5	64		64	12,554			12.8			196				
23 - 27 Jul	5	47		47	9,804			9.4			209				
30 & 31 Jul	2	15		15	3,302			7.5			220				
Jul Totals	21	238		238	45,522			11.3			191				
1 - 3 Aug 73	3	19		19	4,526			6.3			238				
6 - 10 Aug	5	38		38	12,278			7.6			323				
13 - 17 Aug	5	26		26	12,659			5.2			487				
20 - 24 Aug	5	55		55	11,177			11.0			203				
27 - 31 Aug	5	17		17	7,354			3.4			433				
Aug Totals	23	155		155	47,994			6.7			310				
4 - 7 Sep 73	4	15		15	8,482		8,482	3.8			565				
10 - 14 Sep	5	17		17	7,121		7,121	3.4			419				
17 - 21 Sep	5	27		27	10,695		10,695	5.4			396				
24 & 25 Sep	2	31		31	13,710		13,710	15.5			442				
26 - 28 Sep	3	16	15	30	6,055	2,110	8,165	5.3	5.0		378	141		19	5
Sep Totals	19	106	15	121	46,063	2,110	48,173	5.6	5.0	6.4	434	141	398	19	5
1 - 5 Oct 73	5	23	45	68	10,140	3,450	13,590	4.6	15.0		441	77		135	30
9 - 12 Oct	4	19	62	81	13,050	4,595	17,645	4.8	15.5		687	74		174	35
15 - 19 Oct	5	36	79	115	15,730	8,405	24,135	7.2	15.8		437	106		201	35
23 - 26 Oct	4	26	62	88	13,940	7,850	21,790	6.5	15.5		536	127		112	30
29 - 31 Oct	3	16	33	49	8,510	3,990	12,550	5.3	11.0		531	120		32	7
Oct Totals	21	120	281	401	61,370	28,290	89,660	5.7	13.4	13.4	511	101	224	654	137

TABLE 6–5 MUSTARD DEMILITARIZATION PROGRAM TON CONTAINER INCINERATION DATA (Sheet 3 of 4)

OPERATING PERIOD	OPERATING DAYS	TON CONTAINERS INCINERATED			RESIDUE BURNED, POUNDS			AVERAGE T.C.'S BURNED PER OPERATING DAY			AVERAGE RESIDUE BURNED PER T.C.			T.C.'S CUT	DRUMS ASH
		East Furn	West Furn	Total	East Furn	West Furn	Total	East Furn	West Furn	Total	East Furn	West Furn	Total		
1 & 2 Nov 73	2	13	19	32	6,290	5,910	12,200	6.5	9.5		483	311		73	22
5 - 9 Nov	5	32	46	78	14,555	13,315	27,870	6.4	9.2		455	289		144	42
12 - 16 Nov	5	33	50	83	17,715	13,620	31,335	6.6	10.0		537	272		102	26
18 - 21 Nov	4	22	37	59	10,310	6,370	16,680	5.5	9.3		469	172		168	49
26 - 30 Nov	5	34	51	89	18,275	12,700	30,975	6.8	10.2		538	249		256	56
Nov Totals	21	134	203	341	67,145	51,915	119,060	6.4	9.7	16.1	501	256	349	743	195
3 - 7 Dec 73	5	32	39	71	19,570	15,505	35,075	6.4	7.8		612	398		225	57
10 - 14 Dec	5	30	29	59	19,066	12,240	31,306	6.0	5.8		636	422		189	64
17 - 21 Dec	5	24	37	61	13,435	12,320	25,755	4.8	7.4		560	333		138	46
26 - 29 Dec	4	18	27	45	9,610	9,615	19,225	4.5	6.8		534	356		127	44
Dec Totals	19	104	132	236	61,681	49,680	111,361	5.5	6.9	12.4	593	376	472	679	211
2 - 5 Jan 74	4	20	38	58	9,120	6,756	15,876	5.0	9.5		456	178		130	53
7 - 11 Jan	5	29	43	72	12,600	11,350	23,950	5.8	8.6		434	264		207	53
14 - 18 Jan	5	33	38	71	18,123	13,790	31,913	6.6	7.6		549	363		165	34
21 - 25 Jan	5	21	33	54	12,280	10,000	22,280	4.2	6.6		585	303		207	80
28 - 31 Jan	4	21	32	53	11,025	8,260	19,285	5.3	8.0		525	258		183	58
Jan Totals	23	124	184	308	63,148	50,156	113,304	5.4	8.0	13.4	509	273	368	892	278
1 Feb 74	1	4	5	9	1,600	1,045	2,645	4.0	5.0		400	209		40	7
4 - 8 Feb	5	20	31	51	11,120	11,210	22,330	4.0	6.2		556	362		156	56
11 - 15 Feb	5	18	29	47	13,315	14,670	27,985	3.6	5.8		740	506		59	42
19 - 22 Feb	4	14	20	34	10,080	9,042	19,122	3.5	5.0		720	452		41	34
Feb Totals	15	56	85	141	36,115	35,967	72,082	3.7	5.7	9.4	645	423	511	296	139
TOTALS	368	2,423	900	3,323	700,985	218,118	919,103							3,283	965

TABLE 6–5 MUSTARD DEMILITARIZATION PROGRAM TON CONTAINER INCINERATION DATA (Sheet 4 of 4)

OPERATING PERIOD	OPERATING DAYS	TON CONTAINERS DRAINED H	TON CONTAINERS DRAINED HD	TON CONTAINERS DRAINED Total	AGENT DRAINED PER WEEK, POUNDS Total	AGENT DRAINED PER T.C., AVERAGE, LBS. Total	RATIO OF H TO HD T.C.'S DRAINED PER OPERATING WEEK	AVERAGE AGENT DRAINED PER OPERATING DAY LBS/DAY
21 - 25 Aug 72	5	21	9	30			2.3	
28 - 31 Aug	4	19	5	24			3.8	
Aug Totals	9	40	14	54	No Data	No Data	2.9:1	
1 - 8 Sep 72	5	18	6	24	No Data		3.0	
11 - 15 Sep	5	28	10	38	52,769	1,389	2.8	10,554
18 - 22 Sep	0	0	0	0	0	0	0	0
25 - 29 Sep	5	16	9	25	40,724	1,629	1.8	8,145
Sep Totals	15	62	25	87	Incomplete		2.5	
2 - 6 Oct 72	5	14	3	17	19,476	1,146	4.7	3,895
10 - 13 Oct	4	15	6	21	16,569	789	2.5	4,142
16 - 20 Oct	5	27	9	36	46,110	1,280	3.0	9,222
24 - 27 Oct	4	23	8	31	38,934	1,256	2.9	9,734
30 & 31 Oct	2	9	2	11	12,462	1,133	4.5	6,231
Oct Totals	20	88	28	116	133,551	1,151	3.1	6,678
1 - 3 Nov 72	3	8	3	11	13,631	1,239	2.7	4,544
6 - 10 Nov	0		Down for Repairs		4,742			
13 - 17 Nov	5	6	2	8	11,946	1,493	3.0	2,389
19 - 22 Nov	4	16	6	22	31,519	1,433	2.7	7,880
27 - 30 Nov	4	19	7	26	37,488	1,442	2.7	9,372
Nov Totals	16	49	18	67	99,326	1,482	2.7	6,208
1 Dec 72	1	8	3	11	15,408	1,401	2.7	15,408
4 - 8 Dec	5	10	5	15	21,125	1,408	2.0	4.225
11 - 15 Dec	5	27	11	38	50,578	1,331	2.5	10,116
18 - 22 Dec	5	30	9	39	52,727	1,352	3.3	10,545
26 - 29 Dec	3	22	7	29	39,065	1,347	3.1	13,022
Dec Totals	19	97	35	132	178,903	1,355	3.9	9,416

TABLE 6–6 MUSTARD DEMILITARIZATION PROGRAM TON CONTAINER DRAIN DATA (Sheet 1 of 4)

OPERATING PERIOD	OPERATING DAYS	TON CONTAINERS DRAINED			AGENT DRAINED PER WEEK, POUNDS	AGENT DRAINED PER T.C., AVERAGE, LBS.	RATIO OF H TO HD T.C.'S DRAINED PER OPERATING WEEK	AVERAGE AGENT DRAINED PER OPERATING DAY LBS/DAY
		H	HD	Total	Total	Total		
2 - 5 Jan 73	4	17	5	22	31,346	1,425	3.4	7,837
8 - 12 Jan	5	32	12	44	58,911	1,339	2.7	11,782
15 - 19 Jan	5	4	27	31	49,798	1,606	0.1	9,960
22 - 26 Jan	5	0	18	18	29,884	1,660	0	5,977
29 - 31 Jan	3	0	19	19	31,406	1,652	0	10,469
Jan Totals	22	53	81	134	201,345	1,502	0.7	9,152
1 & 2 Feb 73	2	0	15	15	24,647	1,643	0	12,324
5 - 9 Feb	5	0	38	38	63,721	1,676	0	12,744
12 - 16 Feb	5	0	41	41	68,305	1,666	0	13,661
20 - 23 Feb	4	0	38	38	62,822	1,653	0	15,706
26 - 28 Feb	3	0	27	27	44,861	1,659	0	14,937
Feb Totals	19	0	159	159	264,356	1,663	0	13,913
1 & 2 Mar 73	2	0	19	19	30,640	1,612	0	15,320
5 - 9 Mar	5	0	40	40	67,432	1,686	0	13,486
12 - 16 Mar	5	0	37	37	60,429	1,633	0	12,086
19 - 23 Mar	5	45	6	51	70,879	1,390	7.5	14,176
26 - 30 Mar	5	50	25	75	105,747	1,410	2.0	21,149
Mar Totals	22	95	127	222	335,127	1,510	0.7	15,233
2 - 6 Apr 73	5	41	0	41	54,433	1,328	41.0	10,887
9 - 13 Apr	5	48	2	50	69,442	1,389	24.0	13,888
16 - 20 Apr	5	51	6	57	83,595	1,467	8.5	16,719
23 - 27 Apr	5	81	9	90	127,358	1,415	9.0	25,472
30 Apr	1	15	1	16	22,584	1,412	15.0	22,584
Apr Totals	21	236	18	254	357,412	1,407	13.1	17,020
1 - 4 May 73	4	46	4	50	66,623	1,332	11.5	16,656
7 - 11 May	5	41	5	46	63,754	1,386	8.2	12,751
14 - 18 May	5	76	9	85	122,674	1,443	8.4	24,535
21 - 25 May	5	46	5	51	71,135	1,395	9.2	14,227
29 - 31 May	3	43	6	49	69,947	1,427	7.2	23,316
May Totals	22	252	29	281	394,133	1,403	8.7	17,915

TABLE 6–6 MUSTARD DEMILITARIZATION PROGRAM TON CONTAINER DRAIN DATA (Sheet 2 of 4)

OPERATING PERIOD	OPERATING DAYS	TON CONTAINERS DRAINED			AGENT DRAINED PER WEEK, POUNDS	AGENT DRAINED PER T.C., AVERAGE, LBS.	RATIO OF H TO HD T.C.'S DRAINED PER OPERATING WEEK	AVERAGE AGENT DRAINED PER OPERATING DAY LBS/DAY
		H	HD	Total	Total	Total		
1 Jun 73	1	20	2	22	27,904	1,268	10.0	27,904
4 - 8 Jun	5	91	10	101	135,479	1,341	9.1	27,096
11 - 15 Jun	5	96	9	105	136,017	1,295	10.7	27,203
18 - 22 Jun	5	103	11	114	157,797	1,384	9.4	31,559
25 - 29 Jun	5	75	9	84	119,063	1,417	8.3	23,812
Jun Totals	21	385	41	426	576,260	1,353	9.4	27,441
2 - 6 Jul 73	4	74	6	80	116,496	1,456	12.3	29,124
9 - 13 Jul	5	87	8	95	139,491	1,468	10.9	27,898
16 - 20 Jul	5	90	11	101	149,146	1,477	8.2	29,829
23 - 27 Jul	5	67	11	78	111,955	1,435	6.1	22,391
30 & 31 Jul	2	37	4	41	55,312	1,349	9.3	27,656
Jul Totals	21	355	40	395	572,400	1,449	8.9	27,257
1 - 3 Aug 73	3	33	8	41	61,697	1,504	4.1	20,566
6 - 10 Aug	5	49	15	64	81,347	1,271	3.3	16,269
13 - 17 Aug	5	67	22	89	146,633	1,648	3.0	29,327
20 - 24 Aug	5	78	27	105	145,460	1,385	2.9	29,092
27 - 31 Aug	5	66	32	98	139,093	1,419	2.1	27,819
Aug Totals	23	293	104	397	574,230	1,446	2.8	24,967
4 - 7 Sep 73	4	63	21	84	No Data		3.0	
10 - 14 Sep	5	56	34	90			1.6	
17 - 21 Sep	5	53	51	104			1.0	
24 & 25 Sep	2	14	14	28			1.0	
26 - 28 Sep	3	0	0	0			0	
Sep Totals	19	186	120	306	No Data		1.6	
15 - 19 Oct 73	5	13	6	19	38,892	2,046	2.2	7,778
Oct Totals	5	13	6	19	38,892	2,046	2.2	7,778
18 - 21 Nov 73	4	0	4	4	6,164	1,541	0	6,164
Nov Totals	4	0	4	4	6,164	1,541	0	6,164

TABLE 6–6 MUSTARD DEMILITARIZATION PROGRAM TON CONTAINER DRAIN DATA (Sheet 3 of 4)

OPERATING PERIOD	OPERATING DAYS	TON CONTAINERS DRAINED			AGENT DRAINED PER WEEK, POUNDS	AGENT DRAINED PER T.C., AVERAGE, LBS.	RATIO OF H TO HD T.C.'S DRAINED PER OPERATING WEEK	AVERAGE AGENT DRAINED PER OPERATING DAY LBS/DAY
		H	HD	Total	Total	Total		
3 - 7 Dec 73	5	0	1	1	1,420	1,420	0	1,420
10 - 14 Dec	5	0	2	2	1,516	758	0	303
Dec Totals	10	0	3	3	2,936	979	0	294
7 - 11 Jan 74	5	24	0	24	4,967	207	24.0	993
14 - 18 Jan	5	12	0	12	4,142	345	12.0	826
21 - 25 Jan	5	0	4	4	500	125	0	100
Jan Totals	15	36	4	40	9,609	240	9.0	641
11 - 15 Feb 74	5	1	0	1	1,520	1,520	1.0	304
Feb Totals	5	1	0	1	1,520	1,520	1.0	304
TOTALS	308	2,205	856	3,061	3,839,657			

TABLE 6–6 MUSTARD DEMILITARIZATION PROGRAM TON CONTAINER DRAIN DATA (Sheet 4 of 4)

MONTH	TONS OF 100% NaOH USED
AUGUST 1972	112.20
SEPTEMBER	98.83
OCTOBER	120.05
NOVEMBER	73.13
DECEMBER	136.73
JANUARY 1973	155.13
FEBRUARY	192.36
MARCH	241.75
APRIL	224.61
MAY	286.87
JUNE	421.52
JULY	693.28
AUGUST	542.79
SEPTEMBER	480.69
OCTOBER	163.70
NOVEMBER	80.43
DECEMBER	84.00
JANUARY 1974	164.85
FEBRUARY	66.36
	4,339.28 TONS TOTAL

Tonnage derived from monthly caustic inventory calculations.

Table 6–7. MUSTARD DEMILITARIZATION PROGRAM CAUSTIC SODA USAGE

SECTION 7

BUDGET AND COST SUMMARY

7.1 GENERAL

Because of the number of schedule revisions and the complexity of the cost growth factors inherent in each revision, this narrative section will be related to Table 7–1, "RMA Demil - Bulk Mustard Disposal Program Schedules". Each schedule and schedule revision narrative will describe the basic causative factors for the revision and will be followed by a narrative entitled "Cost Impact" which will relate to Table 7–1 and identify the increases by the following categories of cost: Engineering Support, Facilities, Training and Operations, and Surety Guards.

7.2 ORIGINAL SCHEDULE - NO. 1, OCTOBER 1969

7.2.1 SCHEDULE

The original program schedule assumed the turnkey installation of a bulk mustard agent incinerator and the minor rehabilitation of the other existing disposal facilities at Rocky Mountain Arsenal. Plant setup was to be accomplished by August 1970 and the disposal operations were to be completed by March 1971.

7.2.2 ESTIMATED COST

The original cost estimate of $2.94 million for the disposal of the bulk mustard at Rocky Mountain Arsenal was made in October 1969, indicating that the disposal operations would begin in August 1970 and finish seven months later. The project was to pivot about a turnkey type disposal system wherein the contractor was to supply, install, test, and turn over to the Government an operational mustard incineration system.

The original estimate of $2,940,000 included:

Engineering Support		$ 160,000
Facilities		886,000
Training and Operations	T. 94,000 O. 1,714,000	1,808,000
Surety Guards		86,000
	TOTAL	$2,940,000

7.3 SCHEDULE REVISION - NO. 2, MARCH 1970

7.3.1 SCHEDULE IMPACT

The award of the incinerator contract slipped from 15 January to 11 February 1970 when the low bidder was declared "unresponsible financially." Small Business Administration investigation, however, finally led to the contract award to the low bidder, John Tailor and Co., Inc. As a result, a new startup date of 1 October 1970 was established, which delayed program completion until May 1971 (No. 2).

7.3.2 COST IMPACT

The following cost impacts are identifiable with this schedule revision:

A. Engineering Support

The original estimate ($160,000) was increased $50,000 for the development of a scrubbing system for the exhaust gas from the ton container furnace system.

B. Surety Guards

The $20,000 increase in this area was primarily attributed to program stretchout, since the original estimate was for a 13-month period.

C. Training and Operations

Decreases in the training and operations cost estimate of $77,000, were brought about by a reduction in the estimated general overhead rate from $18.07 to $16.95 per direct labor hour. These above cost impacts resulted in a net budget decrease of $7,000.

7.4 SCHEDULE REVISION - NO. 3, AUGUST 1970

7.4.1 SCHEDULE IMPACT

A trucker's strike in the Midwest delayed the shipment of the incinerator/scrubber equipment 45 days and this was reflected in schedule No. 3, made on 19 August 1970. The new startup date was slipped from October to November 1970, with a completion date slippage of 60 days (from May 1971 to July 1971).

7.4.2 COST IMPACT

The following cost impacts are identifiable with this schedule revision:

A. Engineering Support

The need to expand the technical knowledge base required that $489,000 be provided for the following engineering studies: a study on mustard incineration

and the composition of gases and thermal degradation of HD, a determination of conditions required to insure the safety and containment operations that lead to innocuous salts, and evaluation and selection of alarm systems, Levinstein residue disposal studies, and an emission limits study for the Surgeon General's approval.

B. Facilities

Facilities costs increased in October 1970 as a result of the addition of a third unloading booth required to compensate for the slow rate of unloading Levinstein mustard ($206,000) and the increased cost ($41,000 more than estimated) of detectors for stack monitoring system by Tracor, Inc.

C. Training and Operations

The $496,000 increase shown in October 1970 was caused by the following: the extension of the schedule necessitated by the slippage in delivery of the incinerator because of the truckers strike, the need for additional operators for the third cubicle to unload Levinstein mustard, and the establishment of a new system for payment of environmental differentials to Wage Board employees (WB, WL and WS) for exposure to various degrees of hazards.

D. Surety Guards

The increase of $17,000 from the January 1970 estimate was due primarily to Program extension.

7.4.3 COST GROWTH (000)

	October 1969 Original Budget	October 1970 Budget	Variance
Engineering Support	160	699	(539)
Facilities	886	1,133	(247)
Training & Operations	1,808	2,227	(419)
Surety	86	123	(37)
TOTAL	2,940	4,182	(1,242)

7.5 SCHEDULE REVISION - NO. 4, OCTOBER 1970

7.5.1 SCHEDULE IMPACT

A further schedule slippage was necessitated by late receipt of the instrument and motor control panels as reflected in schedule No. 4.

7.5.1 COST IMPACT

A new Budget was not prepared for this schedule revision because the minimal schedule slippage was not deemed significant.

7.6 SCHEDULE REVISION - NO. 5, NOVEMBER 1970

7.6.1 SCHEDULE IMPACT

The installation of the equipment was further delayed by the contractor and he became delinquent on 24 October 1970. Also, a requirement for an environmental impact statement (EIS) was placed on Rocky Mountain Arsenal, and Department of Army approval was required before disposal operations could begin. This delayed startup until 31 March 1971 (No. 5).

7.6.2 COST IMPACT

A new budget was not developed for the schedule revision made in November 1970 because the extent of contractor delays were not fully known at that time; no assessment could be made of the resource requirements for drafting the EIS required.

7.7 SCHEDULE REVISION - NO. 6, JANUARY 1971

7.7.1 SCHEDULE IMPACT

A slippage in the date of the EIS approval postponed the startup date of operations in schedule Number 6 until June 1971.

7.7.2 COST IMPACT

The following cost impacts are identifiable with this schedule revision:

A. Engineering Support

Program stretchouts caused a $17,000 increase in the January 1971 estimate.

B. Facilities

A series of design changes and modifications as outlined below increased the cost estimate by $243,000 in January 1971. The design changes resulting from safety/surety reviews created increased costs in the amount of $87,000 for the addition of an access fence, a monorail to the unloading dock, automation of unloading cradles, addition of a unit heater in the storage pit, change house and lunch/break house modifications, ventilation tests on thaw room and unloading booths, and ton container residue tests. Added requirements for the electrical service and lighting in Building 536, the need to lay new flooring on weekends to avoid interference with the contractors work, the installation of a stairway to the stack monitoring shelter on the roof, masonry work connected with the

salt conveyor, relocation of heating units due to new equipment installation which was not envisioned in the original design, and the extension of the stack to conduct emission level tests combined to increase costs by $50,000. Also, the relocation of the caustic unloading system required longer lines with steam tracing and insulation and resulted in additional costs of $17,000. The addition of a detector for low level concentration of mustard resulted from the more stringent requirements generated during the emission level review by the Surgeon General adding $17,000 in costs. The high residue found in the Levinstein mustard containers led to the inclusion of a scrubber system for the off-gases produced during the burnout of the emptied ton container in the two furnaces, and a decision was made to punch the ton containers to increase the safety to personnel by eliminating the manual removal of plugs and valves. The scrubber and punch systems required $95,000 not covered in the original estimate. These costs were offset by a reduction of $25,000 for filter units, bringing the total to $243,000.

C. Training and Operations

By January 1971, additional costs of $299,000 were identified. The change in the schedule from 3 shifts to 4 shifts required $176,000 for Sunday premium pay and overtime. The extension of the program schedule into FY 1972 caused an increase of $42,000 for labor costs based on 6 percent annual rise in costs. And $81,000 was added for plant clean-up not included in previous estimates.

D. Surety Guards

The culmination of schedule stretchouts effected by schedule revisions 4, 5, and 6 resulted in a cost growth of $27,000 for Surety Guard Support.

A $30,000 increase in the January 1971 estimate resulted from a change in the basis for cost distribution of the Surety Guard force, from a monthly weighted average tonnage to a "time spent" in support of demil, depot and production items in storage. The total increase in budget for surety guards in schedule No. 6 was $57,000.

7.7.3 COST GROWTH (000)

	Budget 20 October 1969	Budget 15 January 1971	Variance
Engineering Support	160	716	(556)
Facilities	886	1,376	(490)
Training & Operations	1,808	2,526	(718)
Surety Guards	86	180	(94)
TOTAL	2,940	4,798	(1,858)

7.8 SCHEDULE REVISION - NO. 7, APRIL 1971

7.8.1 SCHEDULE IMPACT

Functional tests of the Tailor equipment disclosed several problems involving pumps, fans, control valves and the electrical control system. These problems, combined with additional delay on the approval of the EIS (finally received 5 July 1971), the scheduled startup of operations was moved back approximately 30 days.

7.8.2 COST IMPACT

The following cost impacts are identifiable with this schedule revision:

A. Engineering Support

The program stretchout plus increased support requirements for equipment debugging and the added requirements for the development and preparation of SOP's and operating manuals increased the engineering support costs by $150,000.

B. Facilities

The April 1971 increase of $238,000 was due to the additional time required to renovate the existing scrubbing tower, install new packing, move electric power lines, install detector housing, and fabricate and install a second ton container punch. The modification of the mustard feed line and duct work in Building 536 to improve the safety of the interface between the contractor's incinerator and the government's transfer line was not anticipated. The outside work including outdoor lighting, blacktop repair, were previously underestimated. The extension of stack and temporary scaffolds to conduct AEHA gas pollution tests also increased facility costs.

C. Training and Operations

A variety of adjustments to the training and operations costs in April 1971 resulted in a net increase of $336,000. Of this net increase, $82,000 was due to the extension of the training period from 2 to 7 weeks, $38,000 was caused by a wage grade pay raise of 11 percent for the Denver area approved in April 1971 (the previous estimate included only a 6 percent to year change in labor costs), $48,000 was accounted for by an extension of the operating schedule by 6.5 months, and $65,000 was added for direct supervision and clothing treatment support. But a decrease of $132,000 in the previous labor cost estimate was also necessary since the premium pay for Sunday work included the total costs (8 hours at regular pay plus 25 percent premium pay) instead of just the additional costs of 25 percent of hourly rates for premium pay. Adjustments to the overhead charges due to the extension of training from 2 to 7 weeks, the transfer from overhead of certain supervision and clothing treatment costs to direct labor, and a reduction of applied activity overhead resulted in additional overhead charges of $50,000 net. The estimate was

increased $65,000 for material used in training the operators during simulant and live agent runs. $6,000 was budgeted for normal operating supplies, and $157,000 was added due to the increased unit price of caustic (from $80.90 to $109.22 per ton). These material costs were slightly offset by a reduction of $41,000 in the purchase of gloves needed for the glove ports in the unloading booths.

D. Surety Guards

The surety guard budget was originally developed to support 10 guards through 15 March 1971. A total of 39 surety guards were required at Rocky Mountain Arsenal to comply with the provisions of AR 190-3 in providing the type of security required for bulk agents and toxic munitions. As long as any of these agents and munitions remained at Rocky Mountain Arsenal, these guards were required. Financing the cost of this guard force outside of the general overhead cost distribution was made at the direction of HQ, MUCOM in order to maintain a more acceptable relationship of the work force directly identifiable to specific jobs as opposed to those assigned to general post overhead functions. This reapportionment of Surety Guard costs added to the increased force requirements resulted in a $57,000 growth in this portion of the budget.

7.8.3 COST GROWTH (000)

	October 1969 Budget	April 1971 Budget	Variance
Engineering Support	160	866	(706)
Facilities	886	1,614	(728)
Training & Operations	1,808	2,862	(1,054)
Surety Guards	86	237	(151)
TOTAL	2,940	5,579	(2,639)

7.9 SCHEDULE REVISION - NO. 8, JULY 1971

7.9.1 SCHEDULE IMPACT

Unsatisfactory performance of the incinerator/scrubber system due to fuel feeding difficulties, poor air balance in the system and an assortment of startup problems continued to delay the program (No. 8). A further schedule extension was built in when the requirement to conduct pilot operations prior to startup was placed upon Rocky Mountain Arsenal because of recurring operational problems, and to facilitate environmental monitoring.

7.9.2 COST IMPACT

Because of recurring operational problems involving Contractor designed and installed equipment, a new budget was not formulated to coincide with this schedule revision, even though the completion date was extended approximately four months (from December 1971 to April 1972).

7.10 SCHEDULE REVISION - NO. 9, AUGUST 1971

7.10.1 SCHEDULE IMPACT

Another month was lost (No. 9) when operators began having difficulty maintaining a negative pressure within the incinerator/scrubber system. Excessive particulate emissions and salt buildup on the exhaust fans in the ton container furnace system compounded the delay.

7.10.2 COST IMPACT

There was no cost impact reflected in the budget by this schedule revision because of the minor schedule extension of the completion date of one month (from April 1972 to May 1972).

7.11 SCHEDULE REVISION - NO. 10, SEPTEMBER 1971

7.11.1 SCHEDULE IMPACT

Continued unsatisfactory performance of the incinerator/scrubber system, due to mustard feed fluctuations and excessive mustard and particulate emissions caused the three-month schedule slip which was reported in September 1971 (No. 10).

7.11.2 COST IMPACT

The following cost impacts are identifiable with this schedule revision:

A. Engineering Support

Engineering support costs were increased by $160,000 because of recurring problems that dictated schedule extension, and the engineering design change efforts necessitated by the persistent poor performance of the contractor designed and installed equipment.

B. Facilities

The facility cost estimate reached $1,876,000 by 1 September 1971. The cost increase of $262,000 was due to: additional work to renovate the ton container furnace scrubber system, including the relocation of fan and rebuilding of ductwork; modification of the mustard feed system on the incinerator to provide better containment of mustard agent; relocation of two burners on the furnaces to more effectively incinerate gases leaving the furnaces; the more

extensive testing program than originally envisioned due to difficulties encountered during the original test programs.

C. Training and Operations

Another schedule stretchout (anticipated completion date estimated to be August 1972) was reflected in the September 1971 cost estimate. Operating and supporting labor costs increased by $264,000 with $341,000 of applied overhead. An anticipated 30 percent increase in the price of caustic purchased in FY 71 and FY 72 raised the costs another $159,000.

D. Surety Guards

The increase of $4,000 was a minor adjustment in the proration of surety costs.

7.11.3 COST GROWTH (000)

	October 1969 Budget	September 1971 Budget	Variance
Engineering Support	160	1,026	(866)
Facilities	886	1,876	(990)
Training & Operations	1,808	3,626	(1,818)
Surety Guards	86	241	(155)
TOTAL	2,940	6,769	(3,829)

7.12 SCHEDULE REVISION - NO. 11, NOVEMBER 1971

7.12.1 SCHEDULE IMPACT

The startup and completion dates of schedule 11 remained compatible with those dates shown for schedule 10 even though pilot testing indicated that the contractor installed system was not capable of operation within acceptable emission parameters from the incinerator stack.

7.12.2 COST IMPACT

The following cost impacts are identifiable with this schedule revision:

A. Engineering Support

Continued program delays were caused by the alarm levels of the mustard emissions from the incinerator stack. Associated engineering support efforts of personnel from both Edgewood Arsenal and Rocky Mountain Arsenal was required to correct the problem and resulted in a $103,000 increase in the November 1971 estimate.

B. Facilities

No increase in facilities costs were factored into this budget submission as the final assessment was being made of the Tailor System and no definite decision had, as yet, been made which would require additional or substitute demilitarization facilities.

C. Training and Operations

The undesirable alarm level emissions during the initial pilot run required a repeated run in November 1971 which cost $199,000 more than estimated.

D. Surety Guards

The $21,000 increase in costs is attributable to inflationary pressures and the normal employee step-increases.

7.12.3 COST GROWTH (000)

	October 1969 Budget	November 1971 Budget	Variance
Engineering Support	160	1,129	(969)
Facilities	886	1,876	(990)
Training & Operations	1,808	3,825	(2,017)
Surety Guards	86	262	(176)
TOTAL	2,940	7,092	(4,152)

7.13 SCHEDULE REVISION - NO. 12, JANUARY 1972

7.13.1 SCHEDULE IMPACT

A program review at the end of November led to the reorganization of the technical and operational efforts. Extensive pilot operations were started and the initial runs clearly indicated that significant work remained before operations could be initiated. The operation startup planned for December was indefinitely postponed, automatically extending the overall schedule until additional pilot testing was completed (No. 12).

7.13.2 COST IMPACT

The following cost impacts are identifiable with this schedule revision:

A. Engineering Support

Another program extension of seven months was caused by the increased pilot and test operations. Plant modifications greatly increased the engineer support requirements. Edgewood Arsenal increased effort amounted to $70,000 (January 1972).

B. Facilities

Facility costs accelerated rapidly as a result of maintenance and plant modification changes during trial and pilot runs of the disposal system. Unscheduled plant modifications required to correct process problems after such runs resulted in the $420,000 increase shown in January 1972.

C. Training and Operations

Two more months of full-scale pilot operations at $320,000 per month were added to the program to resolve the many operational problems. Five more months of minor testing and training at $80,000 a month were also added. These costs showed up in the January 1972 estimate of $4,865,000.

D. Surety Guards

The program extension projected by schedule number 12 resulted in an increased cost of $70,000 for surety guard support.

7.13.3 COST GROWTH (000)

	October 1969 Budget	January 1972 Budget	Variance
Engineering Support	160	1,199	(1,039)
Facilities	886	2,296	(1,410)
Training & Operations	1,808	4,865	(3,057)
Surety Guards	86	332	(246)
TOTAL	2,940	8,692	(5,752)

7.14 SCHEDULE REVISION - NO. 13, JULY 1972

7.14.1 SCHEDULE IMPACT

By June 1972, the Tailor incinerator/scrubber system was abandoned and mustard incineration in the ton container furnace system was established. Schedule No. 13 was proposed, which showed that the startup of operations could be scheduled on or before 1 July 1972 at a reduced rate of 1 GPM. Installation of a larger capacity electrostatic precipitator and dryer would double the rate, but postpone the ton container decontamination operations until the completion of the bulk agent

disposal. The new completion date of May 1974 extended the Mustard Demilitarization Program schedule completion date by 14 months.

7.14.2 COST IMPACT

The following cost impacts are identifiable with this schedule revision:

A. Engineering Support

When the Tailor System proved inadequate, a greatly expanded engineering team was formed, many engineering tests were conducted, and finally the ton container was converted to the primary mustard incineration system. But this change from the Tailor System to the ton container furnace system required that Rocky Mountain Arsenal provide additional engineering support effort at a cost of $97,000 which involved the use of facilities engineers and draftsmen to document specific work requirements, write definitive work orders, and develop supporting engineering drawings and bills of material. Also, the Edgewood Arsenal support costs for the two-month plant setup period and the total 21-month operational phase were increased by $614,000 bringing the July 1972 estimate for engineering support to more than $2 million.

B. Facilities

The facility cost estimate reached $2,840,000 by July 1972 as a result of trying to modify the Tailor System to permit mustard incineration within the environmental constraints. When the Tailor System proved unsatisfactory, the Ton Container System was converted from a method of disposing the ton container residue into a primary system for disposing both the bulk agent as well as the residue. A total of $150,000 was added to the program to buy an electrostatic precipitator; $60,000 was added to the program as a result of converting the ton container system to burn bulk mustard; $334,000 was added to the program to accomplish the plant setup modifications resulting from many weeks of testing both the Tailor and Ton Container Systems between the period 1 January 1972 and 31 July 1972.

7.14.3 COST GROWTH (000)

	October 1969 Budget	July 1973 Budget	Variance
Engineering Support	160	1910	1750
Facilities	886	2840	1954
Training & Operations	1808	4865	3057
Security Guards	86	332	246
Total	2940	9947	7007

7.15 SCHEDULE REVISION NO. 14 SEPTEMBER 1972

7.15.1 SCHEDULE IMPACT

The September 1972 schedule reflected a month delay in gaining final approval of the revised safety submission. Actual startup of operations began the week of 6 August 1972 at a bulk agent feed rate of 1 GPM and simultaneous burning of ton containers. After the installation of the new precipitator, both furnaces were to be used for bulk agent incineration at a rate of 2 GPM. The emptied ton containers were to be set aside until the completion of the bulk agent disposal. A five-month ton container decontamination was scheduled to commence in December 1973. A two-month cleanup increment was added to the schedule which predicted the completion date of the program in August 1974.

7.15.2 COST IMPACT

The following cost impacts are identifiable with this schedule revision:

A. Engineering Support

The July 1972 engineering support costs were reevaluated and subsequently reduced by $297,000, resulting in the September 1972 estimate for total engineering support cost of $ 1,613,000.

B. Facilities

Additional costs associated with the electrostatic precipitator procurement, a salt compactor to decrease dust hazard for operating personnel and equipment and setup of a ton container saw machine which boosted the total facility cost estimate by $199,000 to $3,039,000 in September 1972.

C. Training and Operations

The training and operations cost estimate was increased by $3,074,000 to $11,157,000 in September 1972 as a result of costs emanating from new personnel requirements for operating the salt compactor and the ton container saw machine, and from evaluation of staff requirements based on experience gained during actual operations.

D. Surety Gaurds

The September 1972 estimate for Surety Guards increased by $22,000 as a result of the total program extension from the previous schedule.

7.15.3 COST GROWTH (000)

	October 1969 Budget	September 1972 Budget	Variance
Engineering Support	160	1,613	(1,453)
Facilities	886	3,039	(2,153)
Training & Operations	1,808	11,157	(9,349)
Surety Guards	86	699	(613)
TOTAL	2,940	16,508	(13,568)

7.16 OPERATIONAL PHASE

No further schedule revisions to the Mustard Demilitarization Program were made. The incineration of Mustard by utilizing both furnaces proved to be a satisfactory method of completing the program.

7.16.1 COST IMPACT

While no further schedule revisions were made, a revised budget estimate was developed in January 1973 to update fund requirements.

A. Engineering Support

The January 1973 budget showed a $19,000 increase in the engineering support estimate due to increased overhead rates experienced at RMA. This was necessitated by the anticipated low level of utilization of the facility, and by reduction in operating personnel reflected in schedule No. 13 from 121 personnel to between 66 and 96 personnel.

B. Facilities

No change.

C. Training and Operations

Increased overhead rates are the cause of the $327,000 increase projected in the January 1973 budget for Training and Operations.

D. Surety Guards

An increased surety guard requirement in addition to inflationary and normal step increases necessitated an upward budget revision of $70,000 to $ 769,000.

7.16.2 COST GROWTH (000)

	October 1969 Budget	January 1973 Budget	Variance
Engineering Support	160	1,632	(1,472)
Facilities	886	3,039	(2,153)
Training & Operations	1,808	11,484	(9,676)
Surety Guards	86	769	(683)
TOTAL	2,940	16,924	(13,984)

7.17 REVISED BUDGET ESTIMATE - DECEMBER 1973

The 10 December 1973 budget estimate was the final budget submittal for the Mustard Demilitarization Program. Because of better than forecasted production rates, the most significant decrease was in training and operations, with minor decreases in funds required for surety guards and engineering support. The December 1973 budget reflected a $32,000 decreased engineer support requirement which resulted in the final engineering support estimate of $1,600.00. The successful test program for burning high residue weight ton containers permitted this reduction in the estimate. These three decreases were offset by procurement and installation of an electrostatic precipitator and a new quench/scrubber not envisioned in the January 1973 budget. The increase of $959,000 resulted in a facilities line item total of $3,998,000 in the December 1973 budget. The table below depicts the cost impact of the final Mustard budget in comparison to the January 1973 budget.

7.17.1 COST IMPACT (000)

	January 1973 Budget	December 1973 Budget	Variance
Engineering Support	1,632	1,600	32
Facilities	3,039	3,998	(959)
Training & Operations	11,484	10,592	892
Surety Guards	769	664	105
TOTAL	16,924	16,854	70

7.18 SUMMARY OF SCHEDULES AND COSTS

The original cost estimate of $2.9 million for the disposal of the bulk mustard at Rocky Mountain Arsenal was made in October 1969, indicating the disposal operations would begin in August 1970 and finish seven months later. However, the mustard disposal operations, rescheduled to take 21 months, were actually started in August 1972 and the total cost of the program was projected to be $16.9 million. This cost growth of $13.9 million was attributed to interrelated administrative delays (poor contractor delivery, and Environmental Impact Statement approval), more stringent technical requirements imposed by regulatory agencies, technical problems, failures to meet technical capabilities expected of initial designs, and higher than anticipated wearout of equipment due to the erosive/corrosive environment caused the increases in the costs, which are broken down into four major parts: engineering support, facilities, training/operations and surety guards.

The original total cost estimate of $2,940,000 included: an engineering support cost of $160,000; a facilities rehabilitation and installation cost of $886,000; a training cost of $94,000; an operations cost of $1,714,000 and a surety guard cost of

$86,000. This cost anticipated a turnkey type disposal system wherein the contractor was to supply, install, test, and turn over to the Government an operational mustard incineration system. The contractor failed to do this and additional effort by the Government was required to perform process development, set up a plant, test it, and establish the disposal program parameters. In addition the final disposal rates were less than anticipated, parts costs were higher, environmental requirements were more stringent, etc.; all of which increased costs. An analysis of the schedule revisions and cost increases which resulted in each of the cost areas indicates that the political and public pressures to complete the program preempted the normal and preferred prototype plant operation which should have preceded the startup of the operational phase. This bypassing of the prototype testing phase of this program contributed significantly to the cost growths.

7.19 FINAL REPORT COST SUMMARY

7.19.1 FINAL COSTS

The final costing of all program expenditures is tabulated below and evidences a program savings from the December 1973 Budget of $1,671,000.

	Final Budget December 1973	Final Cost	Variance
Engineering Support	1,600	1,705	(105)
Facilities	3,998	3,988	10
Training & Operations	10,592	8,874	1,718
Surety Guards	664	616	48
TOTAL	16,854	15,183	1,671

7.19.2 VARIANCE ANALYSIS

A. Engineering Support(+105,000)

B. Facilities ($ - 10,000) - overstated material requirements in the budget preparation.

C. Training and Operations ($ - 1,718,000) - resulted from early program completion.

D. CB Surety ($48,000) resulted from early program completion.

FINAL MUSTARD DEMIL COST REPORT - RMA

Cost Summary

1.	Total Cost			$15,183
	A. Facilities		$3,988	
	COE	$ 11		
	PBA	396		
	EA	684		
	RMA	2,897		
	B. Engineering Support		1,705	
	EA	1,201		
	RMA	504		
	C. CB Surety		616	
	RMA	616		
	D. Training and Operations		8,874	
	EA	39		
	RMA	8,835		
2.	Facilities Cost Summary			3,988
	Labor Cost		691	
	Manhours - 98,542			
	Overhead		1,477	
	Other		1,136	
	EA		684	
	A. Tailor and Ancillary Equip.		1,239	
	Labor Cost	338		
	Manhours - 50,735			
	Overhead	695		
	Other	206		
	B. Precipitators		537	
	Labor Cost	33		
	Manhours - 4,310			
	Overhead	80		
	Other	424		

Table 7–1. COST SUMMARY (Sheet 1 of 5)

C.	Scrubbers		$ 650
	Labor Cost	$ 145	
	Manhours - 19,740		
	Overhead	322	
	Other	183	
D.	Spray Dryer		105
	Labor Cost	18	
	Manhours - 2,420		
	Overhead	46	
	Other	41	
E.	New Unload Booth		48
	Labor Cost	10	
	Manhours - 1,225		
	Overhead	24	
	Other	14	
F.	Preparation of Hydrazine Furnace		52
	Labor Cost	10	
	Manhours - 1,360		
	Overhead	26	
	Other	16	
G.	Modify Building 536		41
	Labor Cost	10	
	Manhours - 1,365		
	Overhead	25	
	Other	6	
H.	Modify Building 537		109
	Labor Cost	35	
	Manhours - 4,697		
	Overhead	17	
	Other	57	
I.	Modify Building 538		235
	Labor Cost	56	
	Manhours - 7,464		
	Overhead	140	
	Other	39	

Table 7–1. COST SUMMARY (Sheet 2 of 5)

J. Exterior Mod. & Misc. Facilities Work			$ 288	
Labor Cost		$ 19		
Manhours - 3,634				
Overhead		51		
Other		218		
3. Engineering Cost Summary				$ 1,705
Labor Cost			207	
Manhours - 18,600				
Overhead			212	
Other			85	
EA			1,201	
4. CB Surety Cost Summary				616
Labor Cost			616	
Manhours - 107,456				
5. Training, Operations, & Cleanup Cost Summary				8,874
Systems Test Pilot Operations & Training			1,811	
Operations			6,917	
a. 1 Gal p/m	2,888			
b. 2 Gal p/m	2,495			
c. Residue Burn	1,534			
Cleanup Report			107	
EA			39	
A. Training, Operations, and Cleanup (RMA)			8,835	
1. Systems Test Pilot Operations & Training		1,811		
Labor Cost	615			
Material	92			
Overhead	858			
Utilities	34			
Other	212			
Labor Manhours	16,308			
Period from 1 July 70 to 5 Aug 72				
2. Operations 1 Gal Per Minute		2,888		
Labor Cost	1,036			
Material	228			

Table 7–1. COST SUMMARY (Sheet 3 of 5)

Overhead	1,410	
Utilities	137	
Other	77	
Labor Manhours	143,236	
Period from 1 Aug 72 to 30 Apr 73		
3. Operation 2 Gal Per Minute		$2,495
Labor Cost	738	
Material	328	
Overhead	1,132	
Utilities	127	
Other	170	
Labor Manhours	95,936	
Period from 1 May 73 to 30 Sep 73		
4. Operation Ton Container Burn		1,534
Labor Cost	533	
Material	118	
Overhead	738	
Utilities	138	
Other	7	
Labor Manhours	70,782	
Period from 1 Oct 73 to 28 Feb 74		
5. Cleanup and Report Writing		95
Labor Cost	39	
Material	0	
Overhead	56	
Utilities	0	
Other	0	
Labor Manhours	3,850	
Period from 1 Mar 74 to 30 Jun 74		
6. Report Writing		12
Labor Cost	12	
Material	0	
Overhead	0	
Utilities	0	
Other	0	

Table 7–1. COST SUMMARY (Sheet 4 of 5)

Labor Manhours Period from 1 May 74 to 30 Jun 74	1,649			
6. Other Costs				$ 4,370
A. Materials Cost			$ 961	
Caustic Transportation (Other Cost)		$ 512		
Pallets		53		
Drums		150		
Protective Clothing		40		
QA Lab		28		
Spare Parts		57		
Control Instruments		13		
Decon Equipment		12		
Misc Operational Material		96		
B. Utilities Cost			436	
Electricity		173		
Gas		85		
Water		75		
Steam		73		
Compressed Air		30		
C. Labor Cost	376,761 Manhours		2,973	
Ind Oper	194,515	1,624		
QA	70,384	547		
Maint	86,677	630		
Log Svcs	12,364	92		
Safety	3,534	26		
Security	9,287	54		

Table 7–1. COST SUMMARY (Sheet 5 of 5)

SECTION 8

ENVIRONMENTAL QUALITY CONSIDERATIONS

8.1 PERIMETER MONITORING

8.1.1 SAMPLING SITES

To establish emission parameters, it was necessary to determine the pollutants already in the atmosphere at the Rocky Mountain Arsenal perimeter. Accordingly, a background, or baseline survey was conducted by USAEHA. Sampling sites were established at nine separate locations around the arsenal perimeter (Figure 8–1) at approximately every 40 degrees. These stations continuously monitored for NO_2, SO_2 and O_3 and suspended particulates with sequential samples on a 6-hour cycle monitor for HCl mist. The USAEHA survey was initiated in October 1969 and was completed in December 1969. Since that time, RMA Quality Assurance personnel continued to operate the stations. Full-scale monitoring, reference to Mustard demilitarization, commenced in May 1970 and continued until March 1974.

8.1.2 ALARM SYSTEM

An automatic alarm system monitors the SO_2 level and wind direction. An SO_2 level of 0.05 ppm or greater for 10 minutes, with the prevailing wind direction coming from the plant to the respective station, would cause an alarm condition which is transmitted to the QA Laboratory, Building 313, by dual channel FM telemetry system. Each of the nine stations is a converted air-conditioned camper trailer and contains the following monitoring equipment:

A. Technicon autoanalyzers for continuous analysis of NO_2 and SO_2. The autoanalyzers perform completely self-contained automatic chemical analysis, with SO_2 and NO_2 concentration readouts on strip chart recorders.

B. Hi-Vol samplers for suspended particulates. All particulates greater than 0.3 microns are collected on preweighed fiber glass filter paper which is transported to the laboratory to be weighed. The weight of particulates per cubic meters of air is calculated and recorded.

C. Mast ozone meters for continuous measuring of total oxidants reported as ozone. This meter utilizes a neutral-buffered potassium percentage iodide oxidation-reduction reaction.

D. Acid mist and chlorides sequential sampler to draw in four, six-hourly samples daily. The actual analysis on the filters is performed in the laboratory on Technicon bench units for acid mist (HCl) and chlorides.

E. Wind equipment. Component parts include wind direction and wind speed. The wind speed and direction are both continuously recorded on Easterline Angus

recorders. Additionally, the wind direction from all nine stations is displayed in the QA laboratory as part of the SO_2 system.

8.1.3 REPORTS

Reports covering all the data generated at the ambient air perimeter stations during the mustard demilitarization program were forwarded to the Colorado Department of Health, Air-pollution Control Division and to USAEHA on a weekly and monthly basis for review and analysis. A final report, Air Pollution Engineering Study No. 99-013-70/75, Analysis of Impact of Mustard Disposal Operations on Ambient Air Quality at Rocky Mountain Arsenal, Denver, Colorado, January 1970 to February 1974 was generated by the USAEHA at the completion of the H demilitarization program which concluded that when data were compared with appropriate ambient air quality standards and with data collected in the Denver Metropolitan area by the US Environmental Health Protection Agency, no significant impact on ambient air quality occurred.

8.1.4 AIR QUALITY STANDARDS

Air quality standards applicable to the demilitarization of mustard at RMA were as follows:

A. Mustard (H or HD): An emission standard of 0.03 mg/m^3 (one-hour average) was established for the mustard demilitarization.[1] Compliance with this emission standard was determined to result in safe ambient air concentration.

B. Sulfur dioxide (as SO_2): An annual arithmetic mean of 0.02 PPM; 24-hour maximum value of 0.1 PPM, not to be exceeded more than once in any twelve-month period; three-hour maximum value of 0.5 PPM, not to be exceeded once per year, and one-hour maximum value of 0.28 PPM, not to be exceeded more than once in any one-month period.[2,3]

C. Acid mist (reported as HCl): Average value of 0.015 PPM, not to be exceeded.

D. Nitrogen dioxide (NO_2): Annual arithmetic mean of 0.05 PPM.[2]

E. Particulates: Annual geometric mean of 60 $\mu g/m^3$; 24-hour maximum value of 150 $\mu g/m^3$, not to be exceeded more than once per year.

F. Oxidants: One-hour maximum not to exceed 0.05 PPM.

Actual results as compared to above standards were included in AEHA Report, dated 19 July 1974. Subject: Summary Report, Impact Mustard Disposal Operation on Air Quality, Rocky Mountain Arsenal, January 1970 to February 1974.

8.2 INPLANT MONITORING

The basic inplant monitoring included ambient air monitoring and process operations analyses.

8.2.1 EQUIPMENT AND PROCEDURES

The inplant air monitoring rapid response (within 30 to 60 seconds) system for mustard detection was the Titrilog II instruments made by Process Analyzers, Inc. of Houston, Texas. These instruments were continuous bromine titration devices in which the mustard molecule was oxidized by the bromine, and an attempt made to maintain the bromine level constant. When additional bromine was required to maintain the bromine balance, this was converted to maintain the signal which is recorded on a Rustrak recorder, and the signal was fed to an audible and visual alarm. The thaw room, where the mustard ton containers were kept to bring the TC's up to temperature for unloading, was continuously monitored by the Titrilog system, and the mustard feed line inclosure at the hydrazine furnace was continuously monitored. The Titrilog II continuously monitored and the alarm responded if the mustard concentration exceeded 0.8 mg/m^3. In event the Titrilog II instrument monitoring the thaw room sounded an alarm, operations inside the thaw room ceased. Personnel did not reenter the area unless clad in Level A clothing. This restriction remained in effect until a subsequent bubbler analysis indicated agent concentration less than 0.01 mg/m^3.

For inplant low-level detection of ambient air, a bubbler system was employed which was capable of detecting 0.004 mg/m^3 of mustard in the air, with a two-hour sampling time. This system drew 18 liters/MIN and passed the sampled air through 10 ML of dibutylphthalate. The mustard was dissolved in the solvent and then transported to the QA Laboratory for analysis. The analysis was performed using an automated technicon by the DB-3 method. DB-3[4-(P-Nitrobenzyl pyridine)] reagent, when mixed with mustard (with a base added) turned a characteristic blue color. The intensity of this blue color was proportional to the quantity of mustard present. The maximum allowable dosage for eye exposure was 2 mg-min/m^3, and for skin or respiratory exposure was 5 mg-min/m^3. In event a bubbler analysis greater than 0.005 mg/m^3 was detected, the QA Laboratory immediately notified the Shift Supervisor. Personnel working in the particular area where the bubbler sample was obtained immediately masked and continued to wear the mask until a subsequent bubbler was received indicating a reading of less than 0.005 mg/m^3. Warning signs were posted, indicating that protective masks were to be worn by all personnel in the area.

When the bubbler analysis greater than 0.009 mg/m^3 was received, the Shift Engineer determined the length of time personnel may remain in the area without changing the Level A protective clothing. The length of time was determined by dividing the maximum allowable dosage with the bubbler analysis. For example, if a bubbler sample was analyzed and the result was .015 mg/m^3 personnel could remain in the area for five hours and 33 minutes.

$$\frac{5 \text{ mg-min/m}^3}{.015 \text{ mg/m}^3} = 333 \text{ minutes}$$

When a bubbler analysis of 0.3 mg/m^3 was received, the particular operations were shut down immediately; and personnel wearing Level A protective clothing performed a complete survey to determine the cause of trouble. The operations did not resume until a satisfactory bubbler analysis was received.

Area (Room Air)	Sample Period	Permissable "H" Concentration
Hydrazine Furnace, Bldg. 538	2 hr	<0.0042 mg/m^3
Unload Booths, Bldg. 537	2 hr	<0.0042 mg/m^3
West Furnace, Bldg. 538	2 hr	<0.0042 mg/m^3
East Furnace, Bldg. 538	2 hr	<0.0042 mg/m^3
Ton Cont. Cutting, Bldg. 540	8 hr	<0.0042 mg/m^3

Bubbler Locations/Sampling Periods

8.2.2 PROCESS OPERATION ANALYSES

Included under process operation analyses for the mustard demil programs were analyses of the following: (a) brine in the scrubber solution; (b) brine in the storage tanks; (c) spray dried salt from the spray dryer; (d) ash residue from the burned mustard ton containers; (e) glycol from the trace system on the H transfer line; (f) ash from the electrostatic precipitator; (g) water from the thaw room sump and unload room trench.

(a) The brine in the scrubber was analyzed by the QA Laboratory for pH, specific gravity and H content in $\mu g/ml$ on an hourly basis during mustard and TC incineration.

(b) The brine in the holding tanks was sampled on a weekly basis by the QA Laboratory for pH, specific gravity and H content in $\mu g/ml$. Maximum H content .25 $\mu g/ml$.

(c) A sample was taken on each shift of the spray dried salt and analyzed by the QA Laboratory for H content, maximum permissible content 0.5 $\mu g/g$. Periodically, additional tests were performed for alkalinity, $\%Na_2CO_3$ and $\%Na_2HCO_3$.

In addition to the inhouse analysis performed by the QA Laboratory, samples of the dried salt were sent to the Spectro-Chemical Laboratory, Division of Coors Porcelain Co. for analysis of heavy metals.[1] (Figure 8–2)

(d) After each H ton container was incinerated and cut in half, a sample of the residual ash was taken and analyzed by the QA Laboratory for the absence of H. The residual ash from the individual TC's was consolidated into numbered 55-gallon drums. Samples were forwarded to Spectro Chemical Laboratory for heavy metals analysis, carbon, sulfur and Fe_2O_3 content.[2] (Figure 8–3)

(e) Liquid samples of the glycol in the H transfer line were taken on a weekly basis and analyzed for H content, pH and specific gravity in the QA Laboratory.

(f) Electrostatic precipitator (ESP) ash samples were analyzed monthly by the QA Laboratory for H content, percent of acidity H_2SO_4, percent of water solubles and percent of insolubles. Samples were forwarded to Spectro Chemical Laboratory for analysis by X-ray diffraction for Fe_3C, Fe_3O_4, αFeO_3, $\alpha FeO(OH)$ and FeS.[3] (Figure 8–4)

(g) The water from the thaw room sump and unload room trench was analyzed by the QA Laboratory for pH, specific gravity and H content on a monthly basis. Additionally, samples were forwarded to Spectro Chemical Laboratories for heavy metals analysis of the water and analysis of the suspended solids.[4] (Figure 8–5)

Additional process controls and analysis included the M18 Detection Kit, blue band monitoring of the incinerated ton containers for the presence of mustard and sampling of each tank car of caustic for percentage of caustic.

A typical analysis of the salt residue is included as Figure 8–6.

8.3 STACK SAMPLING

To ensure that mustard emissions stayed within calculated limits, two detector systems were provided in the stacks where the incineration products are discharged. A detailed survey of both Department of Defense and private industry revealed that no fast response mustard detector system at the required sensitivities was available. Therefore, two separate detection systems were chosen. The first is a quick response (4-minutes) automatic alarm system, which would sound an alarm if the mustard stack effluent concentratin reached 0.5 mg/m^3. The second system monitored the stack to measure average concentrations 0.030 mg/m^3 over a 60-minute cycle period. If either system indicated mustard emissions, operations were immediately curtailed in accordance with Special Operating Procedures.

The monitoring station designed and run by the RMA Quality assurance Office was self-contained and housed the equipment and instrumentation to monitor the high and low mustard concentrations in the stack gas, as well as sulfur dioxide. The low level mustard monitor consisted of glass beaded absorption bubblers with dibutylphthalate solvent which was kept in a constant low temperature bath. Analysis of the bubbler contents for mustard agent was performed in the main QA Laboratory, Building 313. The rapid response, high-level mustard monitor consisted of two automatic sampling tracor gas chromatographs (GC), set up in parallel. This system is much more complex than an ordinary GC, due to the fact that it had to sample the stack gas and analyze for mustard in the presence of SO_2 in a relatively short period of time. A dual column system was used in which a majority of the constituents, other than mustard, were completely separated in the analytical column. The actual detector unit was connected to a strip chart recorder to provide a historical record of H content in the stack effluent. If the H concentrate exceeded 1 PPM, a klaxon horn alarm was activated. The GC system was calibrated once per hour with a known quantity of mustard agent dissolved in hexane.

The continuous SO_2 monitoring was performed by a Dynascience stack system which was a portable compact unit capable of pulling and conditioning hot stack gases preparatory to the analysis of the pollutant. There is a condenser unit within the sampler conditioner to remove the water vapor from the effluent stream; the actual SO_2 sensor was in a unique membrane/electrolyte/electrode combination which undergoes electro-oxidation-reduction when exposed to SO_2. The generated current was amplified, and the output of the amplifier was displayed on a meter, recorded on a strip chart and fed into an alarm system. The detection level for SO_2 was 5 PPM, and the alarm level was set at 470 PPM.

All the daily stack readings were forwarded to the US Army Environmental Health Agency on a weekly basis for review and analysis.

In order to provide an independent check on the validity of the stack sampling, a contract was entered into with the Denver Research Institute of the University of Denver to perform mustard agent HD analyses on the stack effluent and spray dryer salt residue, and alkalinity measurement on the salt residue. The contract was negotiated through Edgewood Arsenal and administered by the Navy under purchase order Nos. DAAAOS-71-M-1274 and DAAA-15-72-M-0518. The University of Denver already had a contract for the Office of Naval Research and therefore, this work was picked up by them. Contract work was initiated in July 1971 and continued until June 1974. Results essentially verified the RMA QA Laboratory findings.

REFERENCES

[1]The Environmental Impact Statement for the Disposal of the Chemical Warfare Agent Mustard, Rocky Mountain Arsenal.

[2]"Federal Register", (Reprint), 36(84), 8186-8201, (30 Apr 1971) EPA.

[3]Colorado Air Quality Control Regulations and Ambient Air Quality Control Standards, Colorado Air Pollution Control Commission; Colorado Department of Health, 9 Dec 1971.

[4]Letter, USAEHA-EA, RMA, 16 Jun 1969, subject: Air Pollution Potential from the Incineration of Mustard, and inclosure.

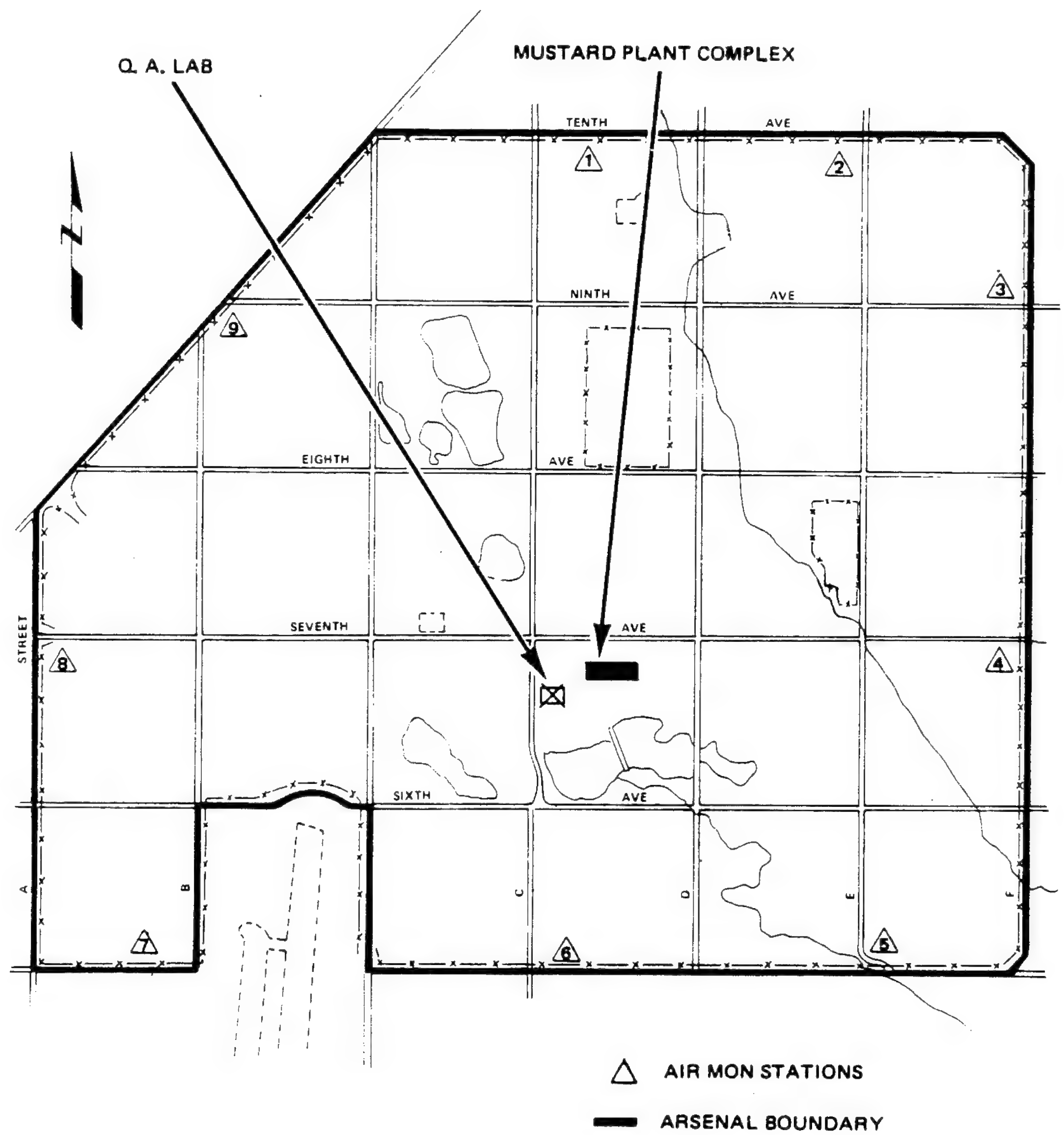

FIGURE 8–1. AIR MONITORING STATION LOCATIONS

Coors / CTRO-CHEMICAL LABORAT(Y
DIVISION OF COORS PORCELAIN COMPANY
GOLDEN, COLORADO, U.S.A.
303-279-6565 Ext. 3202

Mailing Address:
P.O. Box 500
Golden, Colorado 80401

Analytical Report

TO: Rocky Mountain Arsenal
Procurement Division
Bldg 618
Denver, CO 80240

Attention: Ray Ernst

LABORATORY NUMBER	99933
DATE	2-18-74
CUSTOMER ORDER NO.	
MATERIAL	Salt
SAMPLE NUMBER	1-18-74 Bldg. 1703 Dryer

ELEMENT	%	ELEMENT	%	ELEMENT	%	ELEMENT	%
Aluminum (Al)	< 0.01	Gallium (Ga)	< 0.005	Silicon (Si)	0.002	Rubidium (Rb)	< 0.001
Antimony (Sb)	< 0.005	Germanium (Ge)	< 0.005	Silver (Ag)	< 0.001		
Arsenic (As)	< 0.01	Indium (In)	< 0.005	Strontium (Sr)	< 0.001		
Barium (Ba)	< 0.001	Iron (Fe)	0.008	Tin (Sn)	< 0.005		
Beryllium (Be)	< 0.001	Lead (Pb)	< 0.003	Titanium (Ti)	< 0.003		
Bismuth (Bi)	< 0.003	Magnesium (Mg)	0.001	Vanadium (V)	< 0.003		
Boron (B)	< 0.001	Manganese (Mn)	< 0.001	Zinc (Zn)	≤ 0.03		
Cadmium (Cd)	< 0.01	Mercury (Hg)		Zirconium (Zr)	< 0.005		
Calcium (Ca)	0.01	Molybdenum (Mo)	< 0.005	Sodium (Na)	28.73±.05		
Chromium (Cr)	< 0.001	Nickel (Ni)	< 0.01	Cesium (Cs)	< 0.001		
Cobalt (Co)	< 0.01	Niobium (Nb)		Lithium (Li)	0.002		
Copper (Cu)	0.001	Phosphorus (P)	12.9±.1	Potassium (K)	0.2		

☒ Results based on sample as received.
☐ Results based on
☐ Qualitative
☒ Semi-Quantitative (± 50%)
☒ Quantitative (as indicated)

< = Less than
> = Greater than

☐ Atomic Absorption
☒ Optical Emission
☒ Wet Chemistry
☐ X-Ray

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FORM NO. CSL-2 8-73

FIGURE 8–2. DRIED SALT ANALYSIS

Coors /SPECTRO-CHEMICAL LABORATORY
DIVISION OF COORS PORCELAIN COMPANY
GOLDEN, COLORADO, U.S.A.
303-279-6565 Ext: 3202

Mailing Address:
P.O. Box 500
Golden, Colorado 80401

Analytical Report

TO: Rocky Mountain Arsenal
Procurement Division
Bldg. 618
Denver, CO 80240

Attention: Ray Ernst

LABORATORY NUMBER	90975
DATE	5-16-74
CUSTOMER ORDER NO.	
MATERIAL	Ash Residue
SAMPLE NUMBER	Drum No. 1 Bldg. 540 Time 0805

ELEMENT	%	ELEMENT	%	ELEMENT	%	ELEMENT	%
Aluminum (Al)	< 0.01	Gallium (Ga)	< 0.005	Silicon (Si)	0.02	Rubidium (Rb)	< 0.001
Antimony (Sb)	< 0.005	Germanium (Ge)	< 0.005	Silver (Ag)	< 0.001	Fe_2O_3	34.03±.2
Arsenic (As)	2.0	Indium (In)	< 0.005	Strontium (Sr)	< 0.001	Carbon(C)	31.45 ±.5
Barium (Ba)	< 0.001	Iron (Fe)	> 10	Tin (Sn)	< 0.005	Sulfur(S)	21.31±.5
Beryllium (Be)	< 0.001	Lead (Pb)	< 0.003	Titanium (Ti)	< 0.003		
Bismuth (Bi)	< 0.003	Magnesium (Mg)	< 0.001	Vanadium (V)	< 0.003		
Boron (B)	< 0.001	Manganese (Mn)	0.2	Zinc (Zn)	< 0.03		
Cadmium (Cd)	Arsenic Interference	Mercury (Hg)		Zirconium (Zr)	< 0.005		
Calcium (Ca)	< 0.01	Molybdenum (Mo)	0.01	Sodium (Na)	0.003		
Chromium (Cr)	0.003	Nickel (Ni)	< 0.01	Cesium (Cs)	< 0.001		
Cobalt (Co)	< 0.01	Niobium (Nb)		Lithium (Li)	0.001		
Copper (Cu)	0.1	Phosphorus (P)	Iron Interference	Potassium (K)	0.003		

- [x] Results based on sample as received.
- [ ] Results based on ____
- [ ] Qualitative
- [x] Semi-Quantitative (± 50%)
- [x] Quantitative (as indicated)

< = Less than
> = Greater than

- [ ] Atomic Absorption
- [x] Optical Emission
- [x] Wet Chemistry
- [ ] X-Ray

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BY [signature]
Frank B. Schweitzer, Manager

FORM NO. CSL-2 5-73

CUSTOMER

FIGURE 8-3. ASH RESIDUE ANALYSIS

Coors SPECTRO-CHEMICAL LABOI. TORY
DIVISION OF COORS PORCELAIN COMPANY
GOLDEN, COLORADO, U.S.A.
303-279-6565 Ext. 3202

Mailing Address:
P.O. Box 500
Golden, Colorado 80401

Analytical Report

TO: Rocky Mountain Arsenal

LABORATORY NUMBER	90975
DATE	5-16-74
CUSTOMER ORDER NO.	
MATERIAL	Ash Residue
SAMPLE NUMBER	

X-ray Diffraction Results:

Drum No. 1 - Iron carbide (Fe_3C) with magnetite (Fe_3O_4), hematite(α Fe_2O_3) goethite (αFeO(OH)) and iron sulfide (FeS).

Drum No. 2 - Iron carbide (Fe_3C) with iron sulfide (FeS), magnetite (Fe_3O_4), hematite (α Fe_2O_3) and goethite (α FeO(OH)).

Drum No. 3 - Iron carbide (Fe_3C) with iron sulfide (FeS), magnetite (Fe_3O_4), and goethite (αFeO(OH)).

Drum No. 4 - Iron sulfide (FeS) and iron carbide (Fe_3C) with magnetite (Fe_3O_4), and hematite (α Fe_2O_3).

Drum No. 5 - Iron carbide (Fe_3C) with magnetite (Fe_3O_4), hematite (α Fe_2O_3), goethite (α FeO(OH)) and iron sulfide (FeS).

FIGURE 8–4. ESP ASH RESIDUE ANALYSIS

Coors/S. .CTRO-CHEMICAL LABORATO. .
DIVISION OF COORS PORCELAIN COMPANY
GOLDEN, COLORADO, U.S.A.
303-279-6565 Ext. 3202

Mailing Address:
P.O. Box 500
Golden, Colorado 80401

Analytical Report

TO: . Rocky Mountain Arsenal

LABORATORY NUMBER	99636
DATE	1-18-74
CUSTOMER ORDER NO.	
MATERIAL	Suspended Solids
SAMPLE NUMBER	

ELEMENT	%	ELEMENT	%	ELEMENT	%	ELEMENT	%
Aluminum (Al)	1.0	Gallium (Ga)	< 0.003	Silicon (Si)	5.0	Rubidium (Rb)	< 0.0006
Antimony (Sb)	< 0.004	Germanium (Ge)	< 0.003	Silver (Ag)	< 0.0006		
Arsenic (As)	< 0.006	Indium (In)	< 0.003	Strontium (Sr)	0.02		
Barium (Ba)	0.06	Iron (Fe)	3.0	Tin (Sn)	0.03		
Beryllium (Be)	< 0.0006	Lead (Pb)	0.02	Titanium (Ti)	0.02		
Bismuth (Bi)	< 0.002	Magnesium (Mg)	3.0	Vanadium (V)	0.002		
Boron (B)	0.002	Manganese (Mn)	0.02	Zinc (Zn)	0.05		
Cadmium (Cd)	< 0.006	Mercury (Hg)		Zirconium (Zr)	< 0.006		
Calcium (Ca)	> 6.0	Molybdenum (Mo)	< 0.003	Sodium (Na)	3.0		
Chromium (Cr)	0.01	Nickel (Ni)	0.03	Cesium (Cs)	< 0.0006		
Cobalt (Co)	< 0.006	Niobium (Nb)		Lithium (Li)	0.003		
Copper (Cu)	0.05	Phosphorus (P)	Iron Interference	Potassium (K)	0.06		

☐ Results based on sample as received.
☒ Results based on the solids suspended in the water.
☐ Qualitative
☒ Semi-Quantitative (± 50%)
☐ Quantitative (as indicated)

< = Less than
> = Greater than

☐ Atomic Absorption
☒ Optical Emission
☐ Wet Chemistry
☐ X-Ray

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Frank B. Schweitzer, Manager

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FIGURE 8–5. SUSPENDED SOLIDS ANALYSIS (Sheet 1 of 2)

Coors/S. .CTRO-CHEMICAL LABORATO..
DIVISION OF COORS PORCELAIN COMPANY
GOLDEN, COLORADO, U.S.A.
303-279-6565 Ext: 3202

Mailing Address:
P.O. Box 500
Golden, Colorado 80401

Analytical Report

TO: Rocky Mountain Arsenal
Procurement Division, Bldg. 618
Denver, CO 80240

Attention: Ray Ernst

LABORATORY NUMBER	99636
DATE	1-18-74
CUSTOMER ORDER NO.	
MATERIAL	Sump Water
SAMPLE NUMBER	

ELEMENT	ppm ~~%~~	ELEMENT	ppm ~~%~~	ELEMENT	ppm ~~%~~	ELEMENT	ppm ~~%~~
Aluminum (Al)	< 0.3	Gallium (Ga)	< 0.2	Silicon (Si)	10.0	Rubidium (Rb)	< 0.03
Antimony (Sb)	< 0.2	Germanium (Ge)	< 0.2	Silver (Ag)	< 0.03	Chloride	105 ± 5
Arsenic (As)	< 0.3	Indium (In)	< 0.2	Strontium (Sr)	< 0.03	Suspended Solids	90 ± 2
Barium (Ba)	0.03	Iron (Fe)	0.03	Tin (Sn)	< 0.2		
Beryllium (Be)	< 0.03	Lead (Pb)	< 0.1	Titanium (Ti)	< 0.1		
Bismuth (Bi)	< 0.1	Magnesium (Mg)	3.0	Vanadium (V)	< 0.1		
Boron (B)	2.0	Manganese (Mn)	< 0.03	Zinc (Zn)	< 1.0		
Cadmium (Cd)	< 0.3	Mercury (Hg)		Zirconium (Zr)	< 0.3		
Calcium (Ca)	2.0	Molybdenum (Mo)	< 0.2	Sodium (Na)	850 ± 10		
Chromium (Cr)	< 0.03	Nickel (Ni)	< 0.3	Cesium (Cs)	< 0.03		
Cobalt (Co)	< 0.3	Niobium (Nb)		Lithium (Li)	0.3		
Copper (Cu)	< 0.03	Phosphorus (P)	60.0	Potassium (K)	20.0		

[X] Results based on sample as received.
[ ] Results based on ______
[ ] Qualitative
[X] Semi-Quantitative (± 50%)
[X] Quantitative (as indicated)

< = Less than
> = Greater than

[X] Atomic Absorption
[X] Optical Emission
[X] Wet Chemistry
[ ] X-Ray

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CUSTOMER

FORM NO. CSL-2 8-73

FIGURE 8–5. SUSPENDED SOLIDS ANALYSIS (Sheet 2 of 2)

MUSTARD SALTS

CHEMICAL ANALYSIS*

Mercury	1.03 μg/g (ppm)
Cadmium	1.60 μg/g (ppm)
Copper	5.30 μg/g (ppm)
Zinc	3.50 μg/g (ppm)
Lead	<5 μg/g (ppm)
Chromium	<25 μg/g (ppm)
Manganese	<.03 μg/g (ppm)
Silver	<2.5 μg/g (ppm)
Molybdenum	<.1 μg/g (ppm)
Sodium	250 μg/g (ppm)
Potassium	.7 μg/g (ppm)
Soluble Fe	147 (μg/g) (ppm)
Insoluble Fe	2315 (μg/g) (ppm)

$NaCl$	44.3%
Na_2SO_3	23.6%
$NaHCO_3$	5.9%
Na_2SO_4	15.7%
Na_2CO_3	11.9%
Fe_2O_3	.2%
	101.6%

*Analysis by USAEHA on weight composite sample for bulk and drummed salt.

Figure 8–6. TYPICAL SALTS ANALYSIS

SECTION 9

PERSONNEL STRUCTURE AND SUPPORTING SERVICES AT RMA

9.1 RMA ORGANIZATION

The basic organization of RMA is shown in skeleton form on Figure 9–1. The following general information relates only to the conduct of the Mustard Demilitarization Program and is intended to provide general information on the types of services, and in some cases, the number of personnel dedicated to this operation. It should be recognized that there are also administrative organizations beyond those indicated which provided supporting services (such as the Fire Department, Personnel Office, Communications Office, etc.) and an administrative superstructure for the organizations or functions indicated below were greatly involved in the Mustard Operation and are not specifically mentioned (such as the Chief Engineer, Director of Facilities, Director of Logistic Services, Chemical Accident Incident Control Officer, etc.). There are also the usual other supporting services available at an ongoing arsenal, plant, or depot that obviously supported the Mustard Program that are not mentioned (such as road maintenance, administrative supply issuance, testing of the aquifer by engineering, water quality testing by QA, etc.). The following is intended to aid others performing similar demilitarization operations in assuring that they have considered the services or number of people to perform the service indicated below.

9.1.1 MUSTARD OPERATIONS ELEMENT (INDUSTRIAL OPERATIONS DIRECTORATE)

The Product Division was the operating element for the plant. A typical biweekly roster of personnel in the Product Division for Mustard Operation is inclosed (Table 6–2, Item 20). This indicates the size of the Mustard Plant operating force. The basic structure in the plant to man a shift was a Shift Engineer (GS-12), two Foremen (WS-8), four Leaders (WL-8) and 15 Operators. The rationale for the four leaders related to four separate work areas because of geographic considerations, and because of differing kinds of work. The two foremen related to the span of control, with each foreman responsible for two work areas; the shift engineer was the principal onsite technical supervisor. He was furnished with an emergency call list; through it, he had available all the resources of the Arsenal; i.e., he could call for any additional or specialized maintenance support to keep the plant running; he could call for supply support on a 24-hour basis; etc. He also could initiate the emergency disaster control plan (through a call to the Fire Department). Finally, the management structure, through the Commanding Officer, was available to the shift engineer on a 24-hour basis, since the cost impact of any shutdown was considerable and warranted extraordinary action.

The operating personnel were for the most part Chemical Plant Operators (WB-10), Chemical Plant Operator Helpers (WB-7) and Chemical Plant Operator Trainees (WB-5). Besides manning the equipment in the plant, the operating force was utilized for plant maintenance to the extent of painting and cleanup and assisting

the maintenance force in performing any major maintenance task. They were involved in the disaster control plans of the Arsenal; each shift provided an emergency decontamination team. The operating force included the within-plant janitorial and clothing issue services, because of the clearances required (medical, safety, security); the operating force did have a number of qualified truck drivers, forklift operators, etc., to man equipment within the plant.

The requirements for the personnel in the plant; i.e., to be an operator with unlimited access in the plant, required a confidential security clearance, meeting medical work standards developed for each job, and meeting the Suitability and Reliability Regulatory Requirements that relate to a satisfactory psychological history, a satisfactory personnel history, a satisfactory police history, etc., as defined by an Arsenal (and Army) regulation. The operators also had to be trained to assure his safety in the plant; he had to be certified (and periodically recertified) to assure his ability to perform his job, had to observe the "buddy-system" in the plant as a safety/surety requirement.

All the wageboard jobs in the plant were considered an 8 percent hazard differential pay job and all jobs were covered by SOP's.[1]

9.1.2 MAINTENANCE ELEMENT (FACILITIES DIVISION)

The plant maintenance element is best described in two parts: first, the in-plant shift maintenance force; and second, the remainder of the maintenance support for the plant.

First, the in-plant shift maintenance force, for the major portion of the program, consisted of an area maintenance foreman and four personnel per shift. One of the four was a working leader, and the four usually consisted of two millwrights, one electrician and one instrument man. Those in-plant personnel performed the immediate emergency repair tasks with the help of operational personnel. They, of course, were extensively supported by the remainder of the maintenance organization. The in-plant force did perform the preventive maintenance for the plant in accordance with an organized preventive maintenance schedule. They also, to the extent of available time, performed the longer term repair, rebuild, or modernization tasks (assigned maintenance by work order) in addition to the emergency repair tasks and preventive maintenance.

The second portion of the maintenance effort related to a complete, craft shop organization on the Arsenal, capable of building or rebuilding almost any of the plant or the associated equipment. This included an extensive machine shop, electrical shop, instrument shop, sheet metal, carpentry, painting, etc. The shop personnel had the special clearances required to allow their utilization, if necessary, in the plant. Without this capability to perform furnace rebuilding, welding and fan balancing, etc., the plant performance would have severely impaired. Later in the program, the shop elements were consolidated into a separate mustard maintenance organizational element in the Facilities Maintenance Division.

9.1.3 QUALITY ASSURANCE ELEMENT (PRODUCT AND ENVIRONMENTAL ASSURANCE DIVISION)

The Quality Assurance Element was organized into two divisions, one that related to the QA Laboratory and the other the Verification Inspectors.

The laboratory element manned the in-plant, stack monitoring, equipment; they serviced all the bubbler stations and Titralog Alarm stations within the plant. They performed the analysis of bubblers at the Central QA Laboratory (a typical daily report is inclosed); they analyzed samples of brine, salts, ash, caustic, etc., required to support the operation. The number of laboratory personnel in the Mustard Plant (physical science technicians) was six. The number of personnel in the laboratory required to support these analyses in direct support of the Mustard Operation was eight. In a typical month, there were 912 bubblers and 469 brine samples. The Laboratory Support included five personnel to man the perimeter air monitoring stations and the associated analyses. (There also was a military unit of eight personnel attached to RMA from White Sands to support the perimeter air monitoring stations. They perform servicing the stations, maintenance of wind equipment, data compilation, etc.)

The I & V (Verification) inspectors, in direct support of the Mustard Plant, included two inspectors for each shift. They performed the required verification of the accomplishment of various tasks, extracted samples, such as sump water ash, etc., and inspected all material leaving the plant to ensure that it was not contaminated. The verification inspectors' tasks were in the "Records Check List" (Figure 9–2) and the "Verification Check Lists" by building (Figure 9–3). The I & V inspector kept a separate record of each mustard ton container, certified to the weight of mustard emptied, ash recovered, etc., and as such, were an integral part of the procedure for certification of destruction (a supply function). These I & V inspectors also performed verification of clothing laundering and impregnation in support of the Mustard Operation.

The QA jobs were covered by SOP's and laboratory procedures.

Insofar as supervision was concerned relating to the Mustard Operation, a chemist (professional series GS-11) was assigned in the Central Quality Assurance Laboratory as the supervisor of each shift's activities.

9.1.4 SAFETY

The Safety Office had one safety technician assigned to the Mustard Operation on each shift. This technician visited the plant areas on a random basis to perform safety-oriented inspections. The technician was involved in a formal monthly inspection of the mustard activity, in total, and participated in the monthly safety meetings of plant personnel. The Safety Office also provided safety training to all in-plant personnel and participated in the biannual employee orientations of all personnel with mustard clearances, to aid in agent-related symptom recognition, first aid, protective clothing requirements, proper mask fitting, implementation of the buddy-system, etc.; these briefings were accomplished in conjunction with the medical and security elements. The Safety Office administered the annual recall of each mask.

9.1.5 MEDICAL

A condition of employment in mustard was a pre-employment physical to obtain a medical clearance. Each job in the plant had specific medical requirements, and the Medical Facility participated in the development of these standards. The Mustard Plant did not have integral medical support; it was supported by a Medical Facility on the Arsenal approximately 1-1/2 miles from the plant, that was manned whenever any toxic operations were in progress. There were safety and medical requirements for decontaminating equipment in the plant together with decontaminating showers and first aid kits. There was a dedicated ambulance (heated) maintained at the plant; all personnel were trained in first aid. Besides eyewashes, there was M5 ointment in jars available for rapid application. The medical training provided all employees, by the medical staff, concentrated on symptom recognition, first aid and associated equipment locations. The Medical Facility maintained the first aid kits through annual recertification; the Safety Office performed spot checks of them and the foremen were responsible for daily checks.

9.1.6 SECURITY

The Mustard Plant was designated a "Controlled Area" (Ref AR-190-3). A confidential security clearance was required to have unescorted access to the plant. There was one manned guard post associated with the manned entry gate and a vehicle gate. There were two other vehicle gates and two railroad gates (FE-6 fence). The post was manned 24 hours per day and as such, required five guards to man. Security forces were required to escort each shipment from the toxic storage yard; they were part of the convoy to the plant. They controlled access on the other vehicle and railroad gates. They were supplemented on demand by roving security patrols (available by radio). Security forces were involved in manning the toxic storage yard gate, performing the surety (2-hour) inspections of the mustard material in the toxic yard and providing "Security Alert Team (SAT) and Backup Alert Team (BAT)" security team coverage required whenever toxic agent material is involved.

In addition to the normal security tasks, the guards manning the mustard gate were required to check all personnel leaving the plant for indications of possible exposures. All operators were required to wear the "Congo Red" impregnated, outer coveralls. This garment turns blue on contact with mustard (or with an acid or grease).

The Mustard Plant was a "no smoking" area (for the most part) and no food was allowed in the plant. The security forces were involved in enforcing these regulations. All equipment leaving the plant was required to have a QA tag to ensure that it had been inspected for possible contamination. The guard assured that these tags were affixed to all items leaving the plant.

9.1.7 LOGISTIC SERVICES DIRECTORATE

The major Logistic Service functions performing direct support to the Mustard Operation were the Laundry (then a part of Industrial Operations Directorate),

Procurement Division, and Supply Division (in both its receiving warehousing function, and its toxic area storage function).

The laundry required six to nine people in direct support of the Mustard Operation to launder the coveralls, underwear, M5 rubber suits, rubber aprons, masks, gloves, socks, and boots required in the plant and laboratory. This included the impregnation of under clothing with chemical protective components and applying the "Congo Red" to those coveralls requiring it. These operations were covered by SOP's. All operators were required to wear coveralls and to change clothing daily. M3 rubber suits were individually assigned and were not necessarily laundered after each use.

Procurement support varied considerably during the program. It involved facilities acquisition, supply acquisition, spare parts acquisition, etc. Procurement support for some major items was provided by Edgewood Arsenal and Pine Bluff Arsenal, supporting the capabilities of RMA. Some major procurement activities related to the acquisition of the caustic supply, supply of barrels and pallets to store salt, acquisition of major pieces of equipment (i.e., spray dryer, electrostatic precipitator, second scrubbing system), and the acquisition of approximately 540 line items of spare parts.

The receiving and warehousing supply function was responsible for maintaining accountability records for the toxic material during the destruction program; they were responsible for storing and maintaining stockage levels (reordering) spare parts, performing the incoming receiving inspection on spares and material to support the operation; they also manned the parts crib. Approximately 10 personnel were involved in performing the functions in direct support of the Mustard Program; three supply clerks, one shipping and receiving clerk, one typist, three warehousemen, one forklift/truck operator and one working leader. This, of course, was aside from the normal functions of supply (including protective clothing).

The toxic yard handlers involved five people. These personnel performed the daily visual inspection of all stocks, inspected material to be furnished to the plant, changed out defective valves, plugs, etc. They installed bonnets on the ton containers, cleaned them, loaded them on two specially modified trucks and participated in a convoy to the plant. They assisted in unloading the T.C.'s and also hauled away and stored the residues and salts generated by the plant. These operations were covered by SOP's.[2] A typical convoy to the plant included a decontamination vehicle manned by the toxic yard crew, two special trucks with three ton containers each and a security vehicle, which maintained radio contact in case of a problem. The carrier vehicles had special racks to contain a possible spill. The toxic yard crew was the primary decontamination team on the Arsenal. As such, they were a principal participant in the Arsenal's disaster control plan; and had decontaminating trucks and a specially equipped emergency bus, to provide decontaminant monitoring equipment and clothing in event of a problem.

9.1.8 FACILITIES DIRECTORATE

In addition to the Facilities Maintenance support already described above, one other essential supporting service was engineering.

The engineering staff included the complete gamut; electrical and mechanical, civil, and chemical engineering. The engineering staff was responsible for the design of much of the equipment in the plant and in preparing specifications for much of the rest for procurement. They provided procurement support and inspected the installation of any equipment, material, etc., for acceptance by the Army. The engineering staff provided and maintained a complete technical data package for the Mustard Plant.

A supporting function that performed an unusual service in support of toxic operations, was the Fire Department. They are principally responsible for invoking the emergency disaster control plan if necessary for the Arsenal. This, together with their firefighting function, necessitated their continuing awareness of mustard characteristics and operations. They, along with toxic yard handlers, are the primary decontamination capability in event of a toxic release. As such, they are well trained and equipped to cope with toxic material. The Fire Department was the first to respond in the only spill in the Mustard Operation, while the toxic yard personnel shortly thereafter set up a "hot line" to decontaminate personnel involved in the cleanup operation.

9.1.9 MILITARY SUPPORT

The use of military personnel in support of mustard areas (aside from those involved in the management structure of the Arsenal) were in the following areas:

A. To service the air monitoring stations; a meteorological unit from White Sands is assigned for this purpose.

B. To supplement the work force; this occurred principally in the laundry operations and Quality Assurance Laboratory, to provide for peak workload or during that period of time when a buildup in the civilian work force was occurring. The Union Contract essentially prohibited use of military personnel in continuing jobs where a civilian might be displaced.

C. Technical Escort: a unit was available at RMA and while they were not as widely used in the Mustard Program as in other programs, they did provide some escort services and they were frequently used to support engineering tests in the plant. They were available as data takers on a 24-hour schedule and were available to compile and analyze data in support of these tests.

D. Special Services Branch: The Special Services Branch did support the Mustard Program in performing the land dilution operation of the ton container ash and the electrostatic precipitator iron oxide residue.

9.1.10 COMPTROLLER'S OFFICE

Although extensively mentioned elsewhere in the report for the obvious planning, budgeting, funding and cost analysis support, the Comptroller's Office also provided automatic data processing support to the Mustard Program. The two principle

reports they aided in compiling were: a) the main working document on the accountability of ton containers destroyed and the agent weight destroyed, and b) inputting all the perimeter air monitoring data to the Bureau of Standards Computer that performed the extensive summary and analysis of the Arsenal's perimeter air monitoring data.

9.2 SUPPORT FROM OUTSIDE ACTIVITIES

9.2.1 FEDERAL

Within the Government there was considerable essential support provided by many government agencies to operate this program. The principle activities and their areas of contribution were:

A. Edgewood Arsenal - Engineering Support

B. Army Environment Hygiene Agency/Surgeon General/Emission Prevention and Plant Certification

C. DOD Explosive Safety Board - Safety Certification

D. Munitions Command/AMC/DA/DOD Program Approvals

E. EPA/HEW - Plant Certification

F. President's Scientific Advisory Panel - Process Approval

G. Corps of Engineers - Construction Activities Approval

H. Office of the Program Manager for Demilitarization - Management Support and Program Development, Approval and Funding Support

9.2.2 STATE

The State participated in the approval process; the major element involved was the State Air Pollution Control Division.

9.2.3 PRIVATE

Although there was relatively little outside companies' involvement in the program, there were some key contributions in construction and services; among these were the following:

A. Arthur D. Little - Devised a Preventive Maintenance System and Supporting Manuals

B. Precipitair Company - Designed and constructed the electrostatic precipitator

C. Bowen Co - Designed and constructed the spray dryer

9.3 PUBLIC INFORMATION

The Mustard Program at Rocky Mountain Arsenal was preceded by considerable adverse national publicity in the press and TV news media that related to the possible disposal of the stocks of toxic munitions at sea. This plan, dubbed "Chase" as mentioned earlier in this report, intended that large stocks of munitions material, with mustard, phosgene and nerve agent GB be moved from Rocky Mountain Arsenal, by train, under escort, to an East Coast port, to be consolidated with stocks from other locations and disposed of at sea. The initial unfavorable public reaction related to the possible dangers in moving toxic materials cross-country in proximity of populated areas. Additionally, there developed a concern with the possible environmental impacts on sea life that might be caused by this method of disposal. This unfavorable publicity resulted in a reconsideration of the whole proposed procedure of disposal, and although there was one ship loaded with some of the more difficult items to dispose of because they had been encased in concrete, no mustard stocks or other stock from Rocky Mountain Arsenal were included in this limited operation. The public concern also resulted in Federal legislation that limited the Army's ability to move toxic munitions material.

It was in this context that resulted in the decision to dispose of mustard locally at RMA. At the time of this decision, RMA had neither a public information plan nor did it have a full-time Public Information Officer.

As mentioned previously in this report, there was a press conference held at the beginning of the program to announce the anticipated start of production. Due to technical problems and changing environmental requirements, the program's actual startup was delayed considerably, and began in August 1972. Because of the late start, there was again much questioning of the credibility of the Army concerning the actual intent to complete the demilitarization program. This was also heightened by the fact that total stocks of items (or quantities of material) to be demilitarized was classified and therefore not releasable to the public.

During the course of the Mustard Demilitarization Program all of the stocks at RMA were declared excess and the information concerning quantities released.

Also during the course of the Mustard Program, Mr. Tom Pettit of NBC was given authorization to film a segment for his informative program. This segment included film from the Mustard Plant on this operation. The publicity resulting from this TV program was somewhat unfavorable to the Army.

RMA did acquire a full-time Public Information Officer on 11 September 1972. For the major portion of the Mustard Demilitarization Program, there was little interest in operation relating to the Mustard Program in the local (or national) news media.

There was interest early in 1973 concerning the possible transfer of excess stocks of other munitions (GB) to other locations, which was eventually abandoned; and there was a great amount of concern, with the potential impact of demilitarization schedules (because of time-phasing in relation to airport construction) on the use of

an additional, new north-south runway at Stapleton International Airport. This largely revolved around a decision of the DOD Explosive Safety Board to recommend against use of the new runway until demilitarization operations had completed destruction of toxic munitions and material. This publicity resulted in the establishment of specific, simultaneous, schedules for the remaining demilitarization programs at RMA announced by the Secretary of the Army.

Also Congresswoman Mrs. Pat Schroeder of Colorado did recommend a continuing Civilian Review Panel of Arsenal Operations; which resulted in the Government of Colorado appointing a Scientific Advisory Panel to review Arsenal operations.

Most of the above activities did not relate to the Mustard Program, in that there was very little interest in the Mustard Operation at the Arsenal, at least in part because there was no adverse impacts on the surrounding community.

There was a steady flow of important visitors to the Mustard Operation as indicated in the attached listing (Table 9–1) of more important personages who visited the plant. Often there was press coverage of these visits, and for the most part, favorable. Also, there was considerable interest in the GB demilitarization plans during the Mustard Program, and some interest in the Arsenal as a water polluter because of possible pollution from old settling basins, and manufacturing operations. On the whole, the Mustard Program was "low-keyed" deliberately.

The completion of the program was covered by the press, and the coverage was generally favorable to the Army; excerpts from area newspapers are presented herein.

REFERENCES

[1]SOP No. SMURM-O-P-6, dated 28 May 1971.

[2]SOP No. SMURM-L-S, SD-7-70, dated 18 Jun 1971.

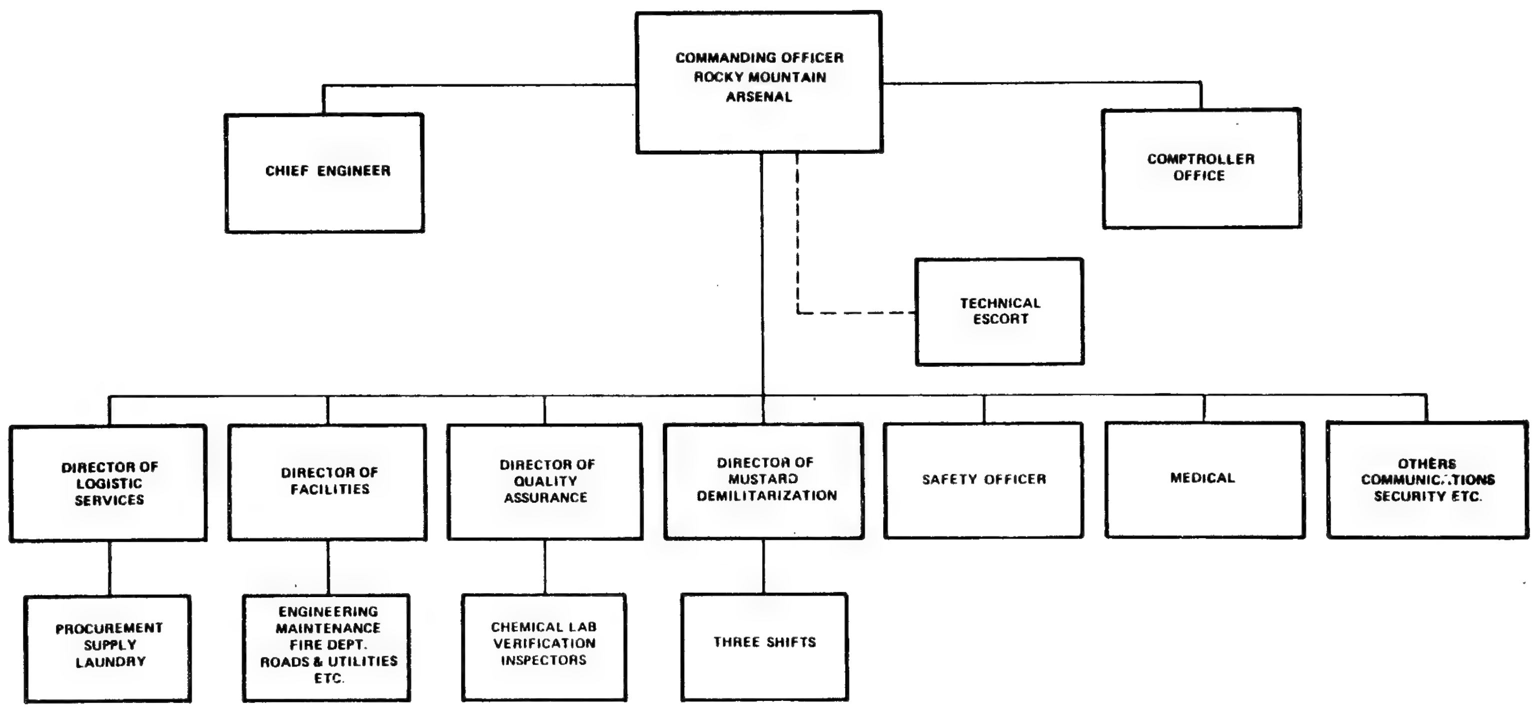

FIGURE 9–1. MUSTARD DEMILITARIZATION PROCESS ORGANIZATION CHART

RECORD CHECK LIST

(AMCR 715-509)

1. SUPPLIER	2. PROCEDURE/INSTRUCTION	3. CK LIST NO.
	SOP SHURM-O-P-6 QA IOP #5	1

TITLE OF RECORD	5. FORM NO.	6. STATION/AREA/DEPARTMENT	7. SCHEDULE/LOG NO.
MUSTARD DEMIL PROGRAM		QUAL ASSURANCE OFFICE	

CHARACTERISTIC

8. NO.	9. DESCRIPTION	FREQ	FORM	QA RECORD AREA PLANT	LAB	BLDG 1
20	Ash Residue Samples (Bldg 540)	ea half of Cont	DD1222	X	X	X
21	Salt Sample from conveyor belt (Bldg 540)	Wkly	DD1222	X	X	X

SCHEDULE

12. BASE PERIOD	13 CKS	14 EFF DATE	13 CKS	14 EFF DATE	13 CKS	14 EFF DATE	13 CKS	14 EFF DATE	13 CKS	14 EFF DATE
WEEKLY										
BI-WEEKLY										
MONTHLY										

REVISION

		18.	19.
15. REVISION NO.	2		
16. DATE	1 Nov 81		
17. INITIALS	SGV	DATE ORIG	SIGNATURE, GOV'T REPRESENTATIVE

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FIGURE 9–2. RECORDS CHECK LIST (Sheet 1 of 2)

RECORD CHECK LIST

(AMCR 715-509)

1. SUPPLIER	2. PROCEDURE/INSTRUCTION	3. CK LIST NO.
	SOP SYOBH-0-P-6 QA IOP #5	1
4. TITLE OF RECORD	**5. FORM NO.** / **6. STATION/AREA/DEPARTMENT**	**7. SCHEDULE/LOG NO.**
MUSTARD DEMIL PROGRAM	QUAL ASSURANCE OFFICE	

CHARACTERISTIC

8. NO.	9. DESCRIPTION (MASTER CHECK LIST ITEM)	FREQ	FORM	QA RECORD AREA PLANT	LAB	BLDG 111
1	Salt sample from conveyor pipe, Bldg 536	Daily	DD 1222	X	X	X
2	Trench Water - Bldg 537	Ea occurance	"	X	X	X
3	Caustic Tank Cars	EA car	DD 1222	X	X	X
4	Blue Band Test of H-HD Ton Containers	Ea Cont.	ContDataCd ADP PO	X X		 X
5.	Blue Band Test of H-HD Container scrap (bonnets,etc)	"	QA Log Book	X		
6	Material transferred & residue weights	"	ContDataCd ADP PO	X X		 X
7	Testing & tagging Material,equipment,clothing drums	Ea Item	Log bk Grn tag	X X		
8	Testing of Mustard transfer line	Monthly	QA Log Bk	X		
9	Testing Congo Red Impregnated clothing	Ea Batch	QALogBk B-314 Q-1 Fm B-314			X X
10	Stack Bubbler - Bldg 538	Hrly	DD 1222	X	X	X
11	Room Bubblers Bldgs 536, 537 & 538	Every 2 Hrs	DD1222	X	X	X
12	Dryer Brine (Bldg 536) & Scrubber Brine (Bldg 538)	Hrly	DD1222		X	X
13	Dynascience SO_2 Monitor	Continuous	Recorder Charts		X	
14	Titralog H Monitor	"	" "		X	
15	Tracor H Monitor	"	" "		X	
16	Perimeter monitoring station's data	"	" " ADP PO		X X	 X
17	Electrostatic Precipitator samples	Mthly	DD1222	X	X	X
18	Ton Container Residue Samples	Ea Batch	DD1222	X	X	X
19	Interlock checks	Mthly	QA Log Book	X		

SCHEDULE

12. BASE PERIOD	13 CKS	14 EFF DATE	13 CKS	14 EFF DATE	13 CKS	14 EFF DATE	13 CKS	14 EFF DATE	13 CKS	14 EFF DATE
WEEKLY										
BI-WEEKLY										
MONTHLY										

REVISION								18.	19.
15. REVISION NO.	2								
16. DATE	[illegible]							DATE / DATE	SIGNATURE, QUAL REPRESENTATIVE
17. INITIALS	[illegible]								

AMC FORM 1180, 2 JAN 64

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FIGURE 9–2. RECORDS CHECK LIST (Sheet 2 of 2)

VERIFICATION CHECK LIST
(AMCR 715-509)

1. SUPPLIER	2. CONT/WO/PO NO.
DRAWING OR PART NUMBER	4. REV. OR ENG. CH OR NO.
5. PART NAME H DEMIL PROGRAM	6. STATION/AREA 536 Salt & Brine Process Area
7. SOURCE OF INSPECTION PROVISIONS OR CRITERIA SOP #SMURM-0-P-6	8. AQL

9. NUMBER	10. DESCRIPTION OF CHARACTERISTICS
1.	H Content in Salt: Limit H = < .5 ug/g
	a. One sample a day, each day of operation.
2.	H Content in Brine + pH & Spec. Gravity (Spray Dryer)
	a. Sampled one each hour of operation & sent to QA Lab for Analysis.
	Limit H = < .25 ug/ml

REVISION					12.	13.
NO.						
DATE						
INITIALS					1/21/82	S G E

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FIGURE 9–3. VERIFICATION CHECK LIST (Sheet 1 of 9)

VERIFICATION CHECK LIST
(AMCR 715-509)

1. SUPPLIER	2. CONT/WO/PO NO.
DRAWING OR PART NUMBER	4. REV. OR ENG. CH OR NO.
5. PART NAME H DEMIL PROGRAM	6. STATION/AREA 537 Thaw Room
7. SOURCE OF INSPECTION PROVISIONS OR CRITERIA SOP #SMURM-0-P-6	8. AQL

9. NUMBER	10. DESCRIPTION OF CHARACTERISTICS
1	H Container limits (Full)
	a. West hall = 6 ea max. b. Center Bay = 72 ea max.
2	Temperature & Time Limits
	a. Hold time in thaw room = 48 hrs min. (placard)
	b. Thaw room temperature maintained at 120° F to 140° F (control charts)
	c. Container contents = 70° F min. (Verify skin temp with pyrometer).
3	H Content in air (room air)
	a. Room bubblers - changed every 2 hrs & sent to QA Lab for analysis
	H Limit = < .0042 Mg/m³
	b. Titralog Monitoring Inst. - continuous sample - strip chart
	H Limit = < .8 Mg/m³
4.	H Content in liquid effluent (wash down trench water), etc.
	a. Trench water H content - sample each occurance & send to QA Lab for
	analysis. H Limit = < .25 ug/ml
5.	Filtration system (west filters)
	a. Air flow resistance test - prefilter (daily by RMA). Limit: 2" water max
	b. Air flow resistance test - Particulate filter (daily by RMA) " "
	c. DOP smoke penetration test of particulate filter: 0143 Tester
	performed by Edgewood Arsenal personnel after each filter change
	Limit = .006%
	d. Freon penetration test of charcoal filter: 0143 Tester

REVISION						
a. REVISION NO.						13.
b. DATE						
c. INITIALS					11-2-72	S.C.P. SIGNATURE, REPRESENTATIVE

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FIGURE 9–3. VERIFICATION CHECK LIST (Sheet 2 of 9)

VERIFICATION CHECK LIST
(AMCR 715-9C9)

1. SUPPLIER	2. CONT NO PO NO.
3. DRAWING OR PART NUMBER	4. REV. OR ENG. CH OR NO.
5. PART NAME H DEMIL PROGRAM	6. STATION AREA 537 Thaw Room
7. SOURCE OF INSPECTION PROVISIONS OR CRITERIA SOP #SMURM-0-P-6	8. A Q L

9. NUMBER	10. DESCRIPTION OF CHARACTERISTICS
5d (cont'd)	performed by Edgewood Arsenal personnel after each filter change
	Limit = 1 ppm
6.	Equipment calibration check, Bldg 537 (visual) Test & Measuring equipment.
	a. Proper function during use & current calibration label & date.
BLDG 537 UNLOAD BOOTH:	
1.	H content in air (room air) H Limit = < .0042 mg/M^3
	a. Room bubblers - changed every 2 hrs & sent to QA Lab for analysis.
2.	H content in liquid effluent (wash down trench water, etc.) H Limits = < .25 ug
	a. Sample each occurance & send to QA Lab for analysis.
3.	Ton container weight (actual weights).
	a. Record actual before & after transfer weights on ton cont. data card.
4.	Filtration system (East filters)
	a. Air flow resistance test prefilter (daily by RMA) Pressure limit: 2" of water max.
	b. Air flow resistance test particulate filter " " " "
	(daily by RMA)
	c. DOP smoke penetration test of particulate filter: Q143 Tester
	performed by Edgewood Arsenal personnel after each filter change.
	Limit = .006%
	d. Freon penetration test of charcoal filter: Q143 tester
	performed by EA personnel after each filter change. Limit=1 ppm

[illegible]					12.	13.
INITIALS					11-2-72	SIGNATURE, Q A REPRESENTATIVE

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FIGURE 9–3. VERIFICATION CHECK LIST (Sheet 3 of 9)

VERIFICATION CHECK LIST

(AMCR 715-509)

1. SUPPLIER	2. CONT/WO/PO NO.

3. DRAWING OR PART NUMBER	4. REV. OR ENG. CH OR NO.
5. PART NAME: H DEMIL PROGRAM	6. STATION/AREA: 537 Unload Booth (cont'd)
7. SOURCE OF INSPECTION PROVISIONS OR CRITERIA: SOP #SMURM-0-P-6	8. AQL

9. NUMBER	10. DESCRIPTION OF CHARACTERISTICS
5.	Blue Band test and green tag issuance (as requested)
	a. All protective clothing, equipment or materials leaving the plant area
	must pass the blueband test and be green tagged to clear guard gate.
6.	Ton container marking after agent transfer.
	a. Stenciling on end of container is to be painted out with a black "X".
	b. The word, "contaminated", is to be stenciled on the end of each container.
7.	Unload booth - H transfer hoses (rubber):
	a. Verify that they are changed once a month (record date in log book).
8	Unload booth - long gauntlet butyl rubber gloves:
	a. Verify that they are changed each time a booth has been used 24 hours.

REVISION					12.	13.
a. REVISION NO.						
b. DATE						
c. INITIALS					11-21-72 DATE	S. G. J. SIGNATURE, REPRESENTATIVE

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FIGURE 9–3. VERIFICATION CHECK LIST (Sheet 4 of 9)

VERIFICATION CHECK LIST
(AMCR 715-509)

1. SUPPLIER	2. CONT/WO/PO NO.
3. DRAWING OR PART NUMBER	4. REV. OR ENG. CH OR NO.
5. PART NAME H DEMIL PROGRAM	6. STATION/AREA 538 TC FURNACE AREA
7. SOURCE OF INSPECTION PROVISIONS OR CRITERIA SOP SMURM-0-P-6	8. AQL

9. NUMBER	10. DESCRIPTION OF CHARACTERISTICS
1.	H Container limit (Empty, contaminated)
	a. Holding area East end of 538 = 20 ea max.
2.	Ton Container weight (Actual weight each container)
	a. Record on ton container data card, after burn weight
3.	Ton container furnace temperature & time interval (Recorder chart)
	a. Ton container serial number is recorded on chart in the segment the contain-
	was in the furnace (significant temperature increase will be indicated during
	agent burn). Completion of burn can be observed visually.
4.	Blue band testing of ton containers & metal parts (bonnets & plugs) Heat Limit 1000° F
	a. If blue band test results are positive - item is to be refurnaced.
	b. If blue band test results are negative - insure that all inapplicable
	markings are obliterated and that "Empty Deconned" is stenciled on both ends
	of ton container, and that a yellow "X" is painted on the metal parts. Enter
	test results on ton container data card.
5. H	transfer line - glycol trace system sampling.
	a. Liquid sample taken once a week and sent to QEAD Lab for analysis: H content,
	pH and specific gravity.
6.	Caustic Sampling (RR Tank Cars)
	a. Each tank car is sampled and the samples are sent to the QEAD Lab to verify
	the percent caustic (50%) ± 2%
7.	H content in air (Room Air)

REVISION					12.	13.
a. ACTION NO.						
b. DATE						
c. INITIALS					11-24-72	S.C.J.
					DATE ORIG.	SIGNATURE, QA REPRESENTATIVE

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FIGURE 9–3. VERIFICATION CHECK LIST (Sheet 5 of 9)

VERIFICATION CHECK LIST

(AMCR 715-509)

1. SUPPLIER	2. CONT/WO/PO NO.
3. DRAWING OR PART NUMBER	4. REV. OR ENG. CH OR NO.
5. PART NAME H DEMIL PROGRAM	6. STATION AREA 538 TC Furnace Area
7. SOURCE OF INSPECTION PROVISIONS OR CRITERIA SOP SMURM-O-P-6	8. AQL

9. NUMBER	10. DESCRIPTION OF CHARACTERISTICS
7 (cont'd)	a. Room bubblers - change every 2 hrs & send to QEAD Lab for analysis ~~Safe H Limit: <.0342 mg/M3~~
	b. Titralog monitoring inst. - continuous sample (strip chart) Safe H limit= .8mg/M3
	c. Dynasciences Monitoring Inst. SO_2 - continuous sample (strip chart) SafeLimit: <475 PPM V/V
8.	Stack Monitoring Instruments:
	a. 1 ea Tracor Mustard Detector - Limit: .5 mg/M^3
	b. 1 ea Dynascience SO_2 Monitor -- Limit: 475 PPM V/V
	c. 1 ea bubbler for minute quantities of H - <.0042 mg/M^3
9.	H content is scrubber brine (Limit: < .25 ug/M + pH & Spec. gravity
	a. Sampled once each hour & delivered to laboratory for analysis.
10.	Test & measuring equipment calibration checks (visual)
	a. Proper function during use & current calibration labels & date.
11.	Records completion:
	a. Insure all data has been recorded on ton container data cards.
	b. Forward reports to ADP and QA Office as applicable.
12	Flue Gas-Dynascience Inst. (Reference QA Report 1-73)
	a. Each Tuesday verify compliance with par 1 of report in regard to calibration of the "on line" unit.
	b. Each Wednesday, verify compliance with par 2 & 4 of report in regard to maintenance of the "off line" pump & air pollution monitor.
	c. Each Thursday, verify compliance with par 3 of report in regard to maintenance of stack sampling system unit.

11. REVISION					12.	13.
a. REVISION NO.	1					
b. DATE	12-7-73					
c. INITIALS	SCJ				DATE / ORIG.	SIGNATURE, QA REPRESENTATIVE

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FIGURE 9–3. VERIFICATION CHECK LIST (Sheet 6 of 9)

VERIFICATION CHECK LIST
(AMCR 715-509)

1. SUPPLIER	2. CONT-WO/PO NO.
DRAWING OR PART NUMBER	4. REV. OR ENG. CH OR NO.
5. PART NAME H DEMIL PROGRAM	6. STATION-AREA 538 TC Furnace Area
7. SOURCE OF INSPECTION PROVISIONS OR CRITERIA SOP SMURM-0-P-6	8. AQL

9. NUMBER	10. DESCRIPTION OF CHARACTERISTICS
12 (contd)	d. The Monday following the first weekend of each month, verify compliance
	with par. 5 of report in regard to the sample conditioning system.

11.						13.
a.	1					
b.						
c. INITIALS	5				DATE ORIG.	SIGNATURE, REPRESENTATIVE

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FIGURE 9–3. VERIFICATION CHECK LIST (Sheet 7 of 9)

VERIFICATION CHECK LIST
(AMCR 715-509)

1. SUPPLIER	2. CONT NO/PO NO.

. DRAWING OR PART NUMBER	4. REV. OR ENG. CH OR NO.
5. PART NAME H DEMIL PROGRAM	6. STATION AREA 540 Cutting Operation
7. SOURCE OF INSPECTION PROVISIONS OR CRITERIA IOP #5 (SARRM-QA)	8. AQL

9. NUMBER	10. DESCRIPTION OF CHARACTERISTICS
1.	Record ton container serial No: Enter in QA Log (each container).
2.	Prepare sample bottle:
	a. Put sample data on label (lot no., container No. & Drum No.)
	b. Place label on bottle.
3.	Collect control sample: Take residue from each half of container and place
	part of sample in sample bottle, and place remainder in split sample device.
4.	Verify ton container & residue container markings:
	a. Ton Container - Lot No. must appear on each container half.
	b. Drum - Lot No. & drum no.
5.	Drum residue sample:
	a. Put sample data on label (Drum No. & date, contents)
	b. Fill sample bottle from split sampler.
	c. Initiate DD Form 1222.
	d. Send sample to QA Lab for analysis to determine H content (samples delivered
	via runner).
6.	Verify stenciling of halves:
	a. After receipt of negative results from laboratory analysis, five yellow "X's"
	are to be stenciled on each container half.
7.	Sign certification on turn-in document.

11. REVISION					12.	13.
a. REVISION NO.	2					
b. DATE	1 Nov 73					
c. INITIALS	S.G.J.				DATE ORIG.	

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FIGURE 9–3. VERIFICATION CHECK LIST (Sheet 8 of 9)

VERIFICATION CHECK LIST
(AMCR 715-509)

1. SUPPLIER	2. CONT/WO/PO NO.
3. DRAWING OR PART NUMBER	4. REV. OR ENG. CH OR NO.
5. PART NAME H DEMIL PROGRAM	6. STATION/AREA 540 Salt Dryer & Druming ~~Operation~~
7. SOURCE OF INSPECTION PROVISIONS OR CRITERIA IOP #5 (SARRM-QA)	8. A Q L

9. NUMBER	10. DESCRIPTION OF CHARACTERISTICS
1.	Collect salt sample:
	a. Place sample data on label & affix label to bottle.
	b. Fill sample bottle from belt conveyor.
	c. Initiate DD Form 1222 & send sample to lab for analysis to determine H
	content & salt constituents.
2.	Visually check salt drums for marking & proper closure.
3.	Notify shift foreman of test results so salt may be moved to storage area.

REVISION					12.	13.
a. REVISION NO.	2					
b. DATE	1 Nov 73					
c. INITIALS	S.G.J				DATE ORIG.	SIGNATURE, Q A REPRESENTATIVE

AMC FORM 1181 2 JAN 64

FIGURE 9–3. VERIFICATION CHECK LIST (Sheet 9 of 9)

22 Aug 72	The Honorable Dudley C. Mecum, Assistant Secretary of the Army
18 Sep 72	BG Raymond Servieres of the French Army - also 16 French Officers
18 Sep 72	CSM D.E. Tennow, US Army Materiel Command Sergeant Major
26 Sep 72	LTG W.W. Vaughan, Deputy Commander, US Army Materiel Command, accompanied by his Aide CPT William Henry
24 Oct 72	The Honorable Henry L.T. Koren, Assistant Secretary of the Army, accompanied by Colonel George E. Bland
31 Jan 73	LTG Richard G. Stilwell, Commanding General of US Sixth Army
20 Feb 73	MG R.B. Smith, Commanding General for Reserve Forces, US Sixth Army, accompanied by 8 officers and civilians
2 May 73	COL Pierre Ricaud and COL Andre Le Blanc of the French Ministry of Defense
16 Jun 73	US Congresswoman Patricia Schroeder of the Colorado First Congressional District
9 Jul 73	The Honorable Wayne Owens, US Congressman, Utah Second District
26 Jul 73	The Honorable John Vanderhoof, Governor of the State of Colorado
3 Aug 73	The Honorable Howard H. Callaway, Secretary of the Army
6 Aug 73	The Honorable William McNichols, Mayor of the City of Denver
29 Aug 73	Mr. George W. Milias, Director of Environmental Quality, Office of the Assistant Secretary of Defense for Health and Environment
8 Sep 73	The Honorable William L. Armstrong, US Congressman Colorado Fifth District
28 Sep 73	MG Joseph W. Pezdirtz, Chief of Staff of US Army Materiel Command
4 Oct 73	Mr. Walter K. Koch, Civilian Aide to the Secretary of the Army
19 Oct 73	Dr. Charles Stevenson, Administrative Assistant to Senator Hughes
22 Oct 73	Mr. Martin R. Hoffman, Special Assistant to the Secretary of Defense

Table 9–1. DISTINGUISHED ARSENAL VISITORS (Sheet 1 of 2)

28 & 29 Oct 73	Mr. William J. Donahoe, Freedom of Information Officer, Chief of Information, Department of the Army
30 Oct to 1 Nov 73	Dr. Louis Medin, Assistant Director for Environmental and Sciences, Office of the Assistant Secretary of Defense
14 Nov 73	Mr. George W. Milias, Director of Environmental Quality, Office of the Assistant Secretary of Defense
29 & 30 Nov 73	BG Pat Crizer, Director, Systems Directorate, Assistant Chief of Staff, Forces Development
23 Jan 74	Governor Vanderhoof's Scientific Advisory Council
14 Mar 74	MG H.D. Smith, Deputy Commanding General for Logistical Support, AMC
21 Mar 74	General Creighton W. Abrams, Chief of Staff, Department of the Army
10 May 74	The Honorable Arthur I. Mendolia, Assistant Secretary of Defense (I&L)
3 - 7 Jun 74	Members of the DOD Explosive Safety Board

Table 9–1. DISTINGUISHED ARSENAL VISITORS (Sheet 2 of 2)

PROMISE UNKEPT 30 MAY 73 DENVER POST

Mayor Says Arsenal 'Failed'

Mayor Bill McNichols counterattacked against the Rocky Mountain Arsenal with a charge Wednesday that the arsenal has failed to live up to a three-year-old promise to dispose of mustard gas and nerve gas stored there.

Denver and the arsenal are engaged in a controversy over a new, 12,000-foot aircraft runway being built into former arsenal ground. The Department of the Army, which controls the arsenal, has refused the city's request for a fly-over easement for airplanes taking off to the north from Stapleton International Airport.

The mayor has termed the $22 million runway essential to the growth of the airport and the city.

NO REASON GIVEN

The Army, he says, gave no reason for refusal of the easement except "safety factor," without details.

The eastern end of the arsenal, where the deadly gas is stored, is a prohibited area for all aircraft—at any altitude. The runways, both the current north-south and that under construction, are more than a mile to the west of the storage area.

The mayor said Wednesday he finds the history of the arsenal and its stored gas "extremely interesting."

In February 1970 the Army promised to dispose of its stockpiled nerve gas within three years and actually expected to finish the job within eight months, he said.

SOME GAS KEPT

But in August of that year, he said, it was announced that some would be kept on hand. Shortly after that, Gov. John Love said he would ask that all nerve gas be removed, McNichols continued.

Later that same month, the mayor said, the Army announced that $14 million would be spent to detoxify the mustard gas, which had to be done before the nerve gas was handled.

So far as he is aware, McNichols said, detoxification hasn't started yet, either on the mustard gas or the nerve gas.

The Army, he said, made a study of the situation in 1969, but no copies of that study have been made available to the city.

STATEMENT UNCLEAR

The mayor said he still doesn't know whether the "safety" mentioned in the easement refusal refers to the stored gas or to structures in direct line with the new runway.

Those include the commander's house and officers' club, with enlisted men's barracks somewhat farther north. The city is willing to replace the first two structures and to discuss the barracks, the mayor said, although the latter is so dilapidated he feels it unjust for the city to shoulder the entire cost.

About $3.5 million already has been spent or committed toward building the new runway, with another $5 million in contracts pending. The conditions of those contract bids expire June 23, and it is feared that bids will go up sharply if new ones are called after that date.

Army Decision On Gas Bombs Due in August

Denver Post

By ANDY ROGERS 7 July 73

Denver Post Staff Writer

Army officials expect to decide by early August whether to move toxic gas from the Rocky Mountain Arsenal on Denver's northern boundary.

Army Secretary Howard Callaway, in a letter to Sen. Floyd Haskell, D-Colo., said Friday that storage of the gas near a major city "is no longer acceptable, no matter how small the risk may be."

Callaway said "action must be taken to eliminate even the remotest possibility of accident as soon as possible" at the arsenal storage site.

The secretary said the Army "is justifiably open to some criticism" for not moving the dangerous stockpile earlier.

Reveals Gas Inventory

In his unusually candid statement, Callaway revealed the arsenal's inventory of mustard gas, [redacted]s and [redacted]ockpile totaling 4,6[redacted] tons of agent—is scheduled to be destroyed.

He declined, however, to say how much agent will be kept in the arsenal's "deterrent" stockpile. That information is classified, he explained.

It is the "deterrent" stock the Army is considering moving from the Denver area, Callaway said in the letter. A decision is expected "within the next 30 days," he said.

Storage of the gases at the arsenal, just north of Stapleton International Airport, has been the subject of controversy for several years.

Critics Fear Crash

Critics have warned of doom should a large aircraft crash in the arsenal's toxic-gas storage area, while Army officials have consistently denied the likelihood of such a disaster.

Several authorities, including Colorado Gov. John Love, have questioned the need to maintain a surplus supply of nerve gas at any location and have hinted that all supplies ought to be destroyed.

However, disposal of nerve-gas agents in the oceans has been banned, and laws make transportation of the dangerous agents across the country extremely difficult.

In his letter to Haskell, Callaway noted several factors in the current delay in disposing of the excess nerve-gas agents. Stringent environmental requirements on both the state and federal level along with contractual and technical difficulties in the disposal process have caused delays in the program, the secretary said.

As a result, the disposal which was to be completed this year is now scheduled for 1976 or 1977, he continued.

The inventory of nerve agents, all slated for detoxification, include 1,476 tons of mustard agent, 1,039 tons of phosgene and 2,089 tons of GB nerve agent. The GB nerve agent is contained in M34 Air Force cluster bombs while the other agents are in containerized form.

Callaway also told Haskell that several bombs that have developed "pinhole" leaks aren't considered dangerous by Army safety experts.

He said casings of four Honest John warheads have leaks, and 222 Honest John bomblets for warheads have developed leaks. All of those items have been sealed in airtight containers to prevent leakage into the atmosphere, he said.

POSSIBILITY REMOTE

About 3,000 M34 clusters have indicated internal bomblet leakage, Callaway wrote to the senator, but "no agent is escaping from the outer casings of the clusters, and the possibility of outside leakage is very remote."

Callaway said the surplus stockpile includes [redacted], 2,0[redacted] tons of nerve gas and 1,039 tons of phosgene.

All of those materials, he said, are being stored above ground, except for the Navy GB nerve gas. That agent is contained in underground storage tanks.

1976 COMPLETION

Because of several factors that have caused delays in Army plans to destroy the surplus stock, it will be at least 1976 before the surplus is eliminated, Callaway reported.

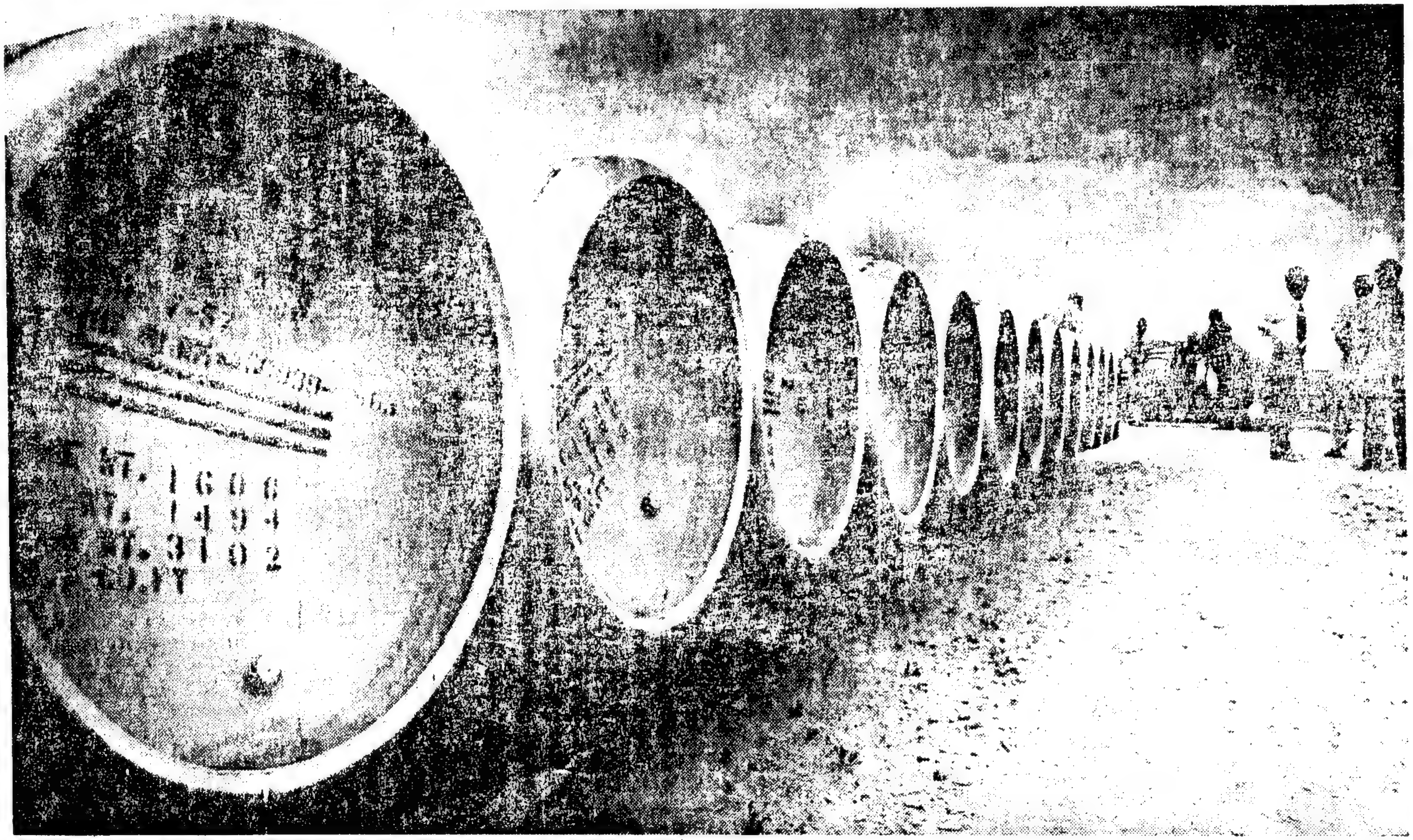
That puts the Army's gas-destruction plan, announced three years ago, nearly four years behind schedule.

The delays, he said, were caused by failure of contractors to meet delivery schedules of equipment needed to destroy the agent and by complicated procedures required by new environmental protection laws.

Callaway's statements were in reply to a letter to the Army which Haskell sent last month.

PUBLIC STATEMENTS REVIEWED

Army Plan on Arsenal Steadfast;



Denver Post Photo by Bill Wunsch

CONTAINERS OF GB NERVE GAS STORED AT ROCKY MOUNTAIN ARSENAL

Large amounts of lethal chemicals still are stored at the arsenal three years after an Army spokesman said they would be moved.

Army's Arsenal Intent Steadfast, With One Slip

DENVER POST 15-7-73

By DAN PARTNER
Denver Post Staff Writer

The Army five years ago—under political pressure—announced plans to dispose of some of the chemical-weapons stock at Rocky Mountain Arsenal and to retain a "small amount" in the interest of national defense.

During that period, a review of public statements shows, the Army — with one possible exception — has reiterated that announced intention.

The exception came on Aug. 29, 1970, when U.S. Rep. Don Brotzman, R-Colo., was told in a letter that the entire supply of chemicals and weapons would be moved to another facility or destroyed at the arsenal.

Yet three years later, large amounts of the lethal chemicals still are stored there.

The 1970 letter was in answer to a Brotzman query concerning the announcement by the arsenal on Aug. 20, 1970, that a supply of nerve gas would be kept in the deterrent stockpile.

The letter, from the chief of plans and operations in the liaison division, was incorrect, the Army said, and shouldn't have been written. The plan announced in 1968 never was altered, Pentagon officials say.

The review of Post stories concerning the arsenal also reveals there has been at least one incident annually, since 1968, when politicians and other "interested" persons "view with alarm" and express "shocked surprise" upon "learning" that a deterrent stockpile will be retained.

No Reaction

There is no indication that the letter to Brotzman brought about any reaction when it was published. But it has been a prime reference point for those who, for various reasons, periodically charge that the Army has double-crossed the public by keeping the stockpile at the arsenal.

Latest reference to the letter came last month when a letter from Brotzman to the secretary of the Army "recalled assurances he had received in 1970 that all toxic substances at the arsenal were to be destroyed or removed." Brotzman, whose 2nd Congressional District once included the arsenal, asked for a full report on the "Army's intentions with respect to further storage of toxic materials at the arsenal."

In addition, Brotzman wrote, "If there has been a change in policy, I would like to know the justification for the change and the reason for the Army's failure to disclose the change."

Motive Unclear

An Army official said last week "no one in the Army has been able to determine" why the 1970 letter to Brotzman was written. It was received by him about a week after the Aug. 20, 1970, announcement by the arsenal that "surplus and obsolete" weapons would be destroyed and that a nerve gas supply would be retained as part of the deterrent stockpile.

This plan again was "revealed" April 11, 1971, when the arsenal said nerve gas would be stored in one-ton containers in a 250-acre "toxic yard" on arsenal property.

The deterrent stock to be retained was made public twice in 1972—once when it was "disclosed" that the arsenal and five other federal facilities in the state housed "ultrahazardous" materials and again when a contract was awarded in the project to dispose of the obsolete and surplus weapons at the arsenal.

Latest furor occurred last May when the Defense Department's Explosives Safety Board denied easement rights over arsenal property in connection with the proposed new 12,000-foot north-south runway at Stapleton International Airport.

The board said, in effect, that commercial aircraft wouldn't be allowed to fly over the arsenal from the new runway

until the stock of hazardous materials on arsenal property was "significantly reduced."

This brought protests that still are continuing but the big outburst came after the announcement June 6 by the arsenal that a "classified" amount of nerve gas would be retained at the arsenal after 4.2 million pounds of the agent was destroyed in the demilitarization project was completed late in 1976.

CALLAWAY BOMBARDED

Congressmen again cried "foul" and Howard H. Callaway, secretary of the Army, was bombarded with demands to remove the agent because of its potential hazard to Denver and environs.

Gov. John Love, who in 1970 expressed surprise that the Army planned to keep a stockpile at the arsenal, again expressed surprise and demanded that the agents be removed.

Brotzman said he was never "informed of any Army change in plans after he was told in 1970 that all toxic material would be destroyed or removed from the arsenal."

Sen. Floyd Haskell, D-Colo., said he was "appalled" and threatened to request an investigation by the General Accounting Office (GAO) unless he got a "prompt report" from the Army.

SEARCH FOR OPTIONS

Rep. William Armstrong, R-Colo., whose new 5th district now includes the arsenal, was told by Callaway that the Army was "looking for options" in the move to solve the nerve gas "problem." These options, Callaway said, included burying the nerve gas in steel and concrete vaults on arsenal grounds or to moving it to a remote site somewhere else in the United States.

The next communication from Callaway came July 6 in a letter to Haskell promising a decision early in August on what will be done with the deterrent stockpile.

Storage of the nerve gas near a major city "is no longer acceptable, no matter how small the risk may be," Callaway said, and "action must be taken to eliminate even the remotest possibility of accident as soon as possible."

Last week it was reported in Washington that there existed a "live possibility" that the gas would be moved from the arsenal to the Pueblo, Colo., Army Depot.

UTAH SITE

Armstrong had previously suggested that the gas be moved to the Army Depot at Tooele, Utah, where a quantity of the gas now is stored.

First hint that Pueblo was being considered came from Sen. Wallace F. Bennett, R-Utah, who suggested the Colorado site as a "less risky and less complicated" operation than moving the material to Tooele.

While the deterrent stockpile has been the major target for arsenal critics, the delay in starting the detoxification of 21,115 M34 cluster bombs containing nerve gas has been frequently noted.

The process, now more than two years behind schedule, has been delayed, the Army says, for two principal reasons: designing and manufacturing the highly complex equipment ("almost beyond the state of the art") and compliance with stringent environmental protection and safety regulations.

COST SKYROCKETS

Cost of the program has zoomed from $9 million in 1969 to more than $33 million now.

The Army also has been accused of being "less than candid" and "evasive" in answering queries from congressmen and the news media. The service received several blasts of criticism when it was revealed that the lethal VX agent and another biological agent, wheat stem rust, were also stored on arsenal grounds.

The materials, which no longer are at the installation, are classified, a spokesman said, "and we make no announcements about classified materials.

"Besides," he said, "nobody ever asked."

The Colorado Health Department is concerned because the Army refuses to reveal the quantity of the deterrent stockpile. The department needs to know, a spokesman said, to adequately prepare a contingency plan in evene of a catastrophe.

SIZE NOT GIVEN

The size of the stockpile, an Army spokesman said, is revealed only to those with a "need to know." It wasn't mentioned in the last arsenal inventory sent to the health department, and the department has asked that it be informed of the amount for planning purposes.

The arsenal has recommended to Washington headquarters that the information be supplied.

The arsenal was built in 1943 for the manufacture of toxic products and incendiary munitions for World War II. In 1950 a $40 million addition was made, and four years later The Denver Post revealed that the new facility was manufacturing GB — nerve gas.

Its mission completed, the GB facility was shut down in 1957 and put on standby status.

"We haven't made GB since 1957, we're not making it now," an arsenal spokesman said. "We are not filling any weapons with it. All of the GB here is in weapons or in bulk containers."

TIMING OF PROTESTS

Protests by politicians about the arsenal's mission and its products during the years appear to be at random periods, although more intense when an election is pending.

To some observers, however, criticism of the arsenal seems to coincide with Denver's expansion plans for Stapleton International Airport.

An Army officer, admittedly biased, said "Whenever Denver needs more land for its airport, someone pulls the chain and politicians start blasting the arsenal."

Following are the highlights in the arsenal history, as revealed in Post files, beginning in 1963:

1963—Business boomed in preparing weapons for chemical warfare as the administration discarded the concept of "massive retaliation" with nuclear weapons. . . . Wildlife lovers protested that ducks were being killed by dieldrin contained in waste water in industrial lakes used by Shell Chemical Co., a tenant on arsenal land. . . . Arsenal gave 474 acres of land to the city, which promptly asked for an additional 805 acres.

1964—City buys 805 acres for $1.8 million.

1965—Arsenal employe, Julian Sanchez, 31, died following exposure to chemical fumes.

1966-67—Arsenal well probed as earthquake cause.

1968—An election year and the arsenal is a live target for politicians. Pressured for "assessments" and "studies" of its inventory and operations, arsenal officials announced that some stocks would be destroyed but that a "small amount" of nerve gas would be kept to "continue its mission in support of national defense." . . . The 12,045-foot-deep well, used for disposal of waste water and suspected for three years of causing earth tremors in the area and of polluting subsurface water, was being pumped dry. . . . Army announced it planned to remove "most" of the nerve gas and bury the remainder to make it safe from earthquakes and plane crashes. . . . It was suggested that the gas be moved to Tooele, Utah, and Denver officials talked of obtaining all of the arsenal property for airport expansion. . . . Adams County officials voiced opposition to expansion of the airport in their direction and the Army said it had no intention of vacating the property.

NIXON PLEDGE

1969 — President Nixon denounced germ warfare, promised to destroy biological warfare weapons and renounced first use of chemical weapons by the United States. This brought renewed demands that the arsenal be closed. . . . Arsenal gave 651 acres of land to Denver for new runway. . . . Well is pumped dry. . . . Preparations were made to burn World War I mustard gas supply and to start the "demilitarization" of nerve gas bombs in February 1970. . . . Department of Transportation stopped shipment of phosgene gas, leaving 1,294 cylinders of the agent at the arsenal. . . . Plans to sink it in the Atlantic Ocean were dropped following recommendation of a National Academy of Sciences committee.

1970 — Announcement that entire stock of VX gas had been destroyed was first hint the agent was on arsenal grounds . . . Announcement that the 1,604,132 M-125 bomblets (each containing 2.6 pounds of nerve gas) had no propellant charge but each contained a half pound of tetryl for an explosive charge; 76 bomblets make up one M-34 bomb; 21,107 M-34 bombs on hand . . . Army said reported plan to ship nerve gas from other U.S. sites to Denver was "never considered" . . . Mustard gas inventory announced as 2,457 one-ton containers (420,000 gallons) of Levenstein type and 951 one-ton containers (164,000 gallons) of distilled type . . . Announcement that M-34 bombs contained 463,622 gallons of nerve gas agent and 882,273 pounds of tetryl bursters . . . Announcement (Aug. 20) that a supply of nerve gas will be retained as part of the deterrent stockpile . . . Project Chase, Army said, would dispose of only the "surplus and obsolete" nerve gas weapons . . . National Academy of Sciences reported that 2,200 "leaky" M-34 bombs had been disposed of at the arsenal "over a period of years" . . . Colorado Gov. John Love "surprised" to learn that a deterrent stockpile would be kept at the arsenal and said he would see about getting it moved out of the state . . . Rep. Don Brotzman, R-Colo., said he received a letter from the Army assuring him that the entire stock of nerve gas would be removed from the arsenal or disposed of at the arsenal . . . Army said destruction of mustard gas would begin in October and demilitarization of M-34 bombs would begin in spring of 1971 . . . "Biological agents" reported to be stored at arsenal.

PROGRAM LAGS

1971 — Demilitarization program lags because of foulup in "administrative machinery," cost estimate up from $9 million to $17.6 million . . . Announcement made that 250-acre "toxic yard" area will contain one-ton containers of nerve gas as a deterrent stockpile . . . Burning of mustard gas scheduled to start . . . Request received for strip of land, three miles long and 3,000 feet wide, for relocation of Denver railroad yards . . . Ten acres of land given to Denver for new water pumping station.

1972—Arsenal was named as one of six federal facilities in Colorado storing "ultrahazardous" materials . . . Contract for $1.5 million awarded as last major step in setting up system to destroy nerve gas bombs . . . Destruction of "biological agent"—wheat stem rust—completed.

1973—Arsenal officials hosted news media on tour (in June) of nerve gas detoxification facility; announced the $33 million project would start Oct. 1 with destruction of 18 bombs daily by force of 33 men; that 2,588 gallons of the nerve gas had been destroyed during a test run in mid-April . . . Announcement made that a classified amount of nerve gas would remain at the arsenal as part of a deterrent stockpile . . . Announced that two-year delay in destroying nerve gas was due to the necessity for "absolute safety and security," the "concern" about pollution and because of the magnitude of the task of designing and manufacturing "first of a kind" equipment . . . Department of Defense Explosives Safety Board denies Denver request for easements involving arsenal land and air space in connection with construction of new 12,000-foot-long runway. . . State health department requested "full accounting" of inventory at arsenal, noting that inventory given the department in 1972 didn't mention deterrent stock . . . Army headquarters said Denver may be given easements for new runway in late summer of 1976 . . . Secretary of the Army said (July 6) that announcement would be made "within 30 days" about what would be done with the deterrent stockpile of nerve gas at the arsenal.

LONGMONT TIMES CALL
12-1-73

Mustard Gas Burning Continues at Arsenal

DENVER (AP) — Officials at the Rocky Mountain Arsenal northeast of Denver reported Wednesday that about a fourth of the 584,000 gallons of mustard gas stored there has been destroyed.

The burning of the gas was started last August and will be completed in August 1974, according to Maj. Andrew Blasco, deputy commander at the arsenal..

Destruction of 500,000 gallons of deadly nerve gas stored at the arsenal is scheduled to begin in October and be completed in about three years.

No date has been set for the start of the disposal of the high-, ly toxic phosgene gas. The Army is exploring the possibility of simultaneous disposal of the phosgene and nerve gas, Blasco said.

The destrouction of the gases is in compliance with President Richard Nixon's November 1969 order requiring elimination of all obsolete chemical-filled munitions and all biological warfare stockpiles except those required for national defense purposes. Blasco said.

AREA WATER IN 1955-56

THE DENVER POST Monday, Feb. 25, 1974 3

Pollution by Arsenal Told

By FRED GILLIES
Denver Post Staff Writer

The Rocky Mountain Arsenal contributed in 1955-56 to pollution of underground water northwest of the facility, Lt. Col. Gerald G. Watson, arsenal commander, confirmed Monday.

Watson made the confirmation as he commented on a recently released Army report indicating that during the 27 years ending in 1969, no records were maintained on the quantities or types of chemicals discharged into the arsenal's waste-disposal system.

REQUEST MADE

The Army made the report in reply to a request made last July by Rep. Schroeder, D-Colo., who asked for a list of all waste materials the arsenal and its lessees, the Shell Chemical Co. and the Chemical Nostrip Co. are discharging into the air, ground, ponds or streams at the arsneal.

The arsenal, Watson said Monday, "now probably has the best monitoring system in existence. That's the point to be made, rather than going back to 1942 and looking at this thing from that standpoint."

Watson noted that during the period 1942-69, there was no requirement on federal installations or the industrial complex to maintain records on disposal of wastes.

BETTER THAN STATE

The standards now being achieved at the arsenal in relation to disposal of wastes there are "100 times better than state standards," Watson said.

Watson said that the 1955-56 pollution of underground water northwest of the arsenal "probably did come from Lake "A," the arsenal's waste-disposal pond which was put into use from the time the arsenal began operations in 1942 until 1954.

"The characteristics (of this pollution) were never precisely determined — it's a very complicated thing,'' Watson said.

WELLS DRILLED

He confirmed that after this pollution was discovered, about 119 wells were drilled, on and off the arsenal, to monitor the aquifer (underground water source) as it flows from the arsenal northwest toward the South Platte River.

These wells are sampled periodically and analyzed for the chloride ion which generally is accepted by the scientific community as an indicator of whether the arsenal is contributing to aquifer pollution, Watson said.

The Tri-County Health Department and Colorado Health Department jointly monitor these wells with the arsenal, and there has been a significant decrease in the chloride ion concentration since 1956 to the present, Watson said.

LETTER SENT

The reference to the 1955-56 pollution was in a Sept. 5, 1972, letter accompanying the Army's report to the Colorado congresswoman. This letter was sent to Rep. Don Brotzman, R-Colo., by Maj. Gen. Erwin M. Graham Jr., commander of the headquarters of the Army's Munitions Command, Dover, N.J.

The Army's report noted that "no data are available to definitely specify what was introduced into the waste disposal pond (Lake A) from 1942 to 1954.

"It could be assumed that there were some quantities of all chemicals, used or manufactured at the arsenal, deposited in the waste-disposal pond as detoxified, neutralized salt solutions," the report said.

VARIOUS FORMS

"These salts or brine solutions," the report said, "could have included some detoxified mustard or Lewisite (gases) and some sulphur, chlorine or arsenic in various forms of salt solutions. These wastes could also have included some washdown waste water from the incendiary lines, or the arsenal's clothing treatment plant, and could have contained some phosphorous compounds or chlorinated paraffin."

In 1946, the report said, the arsenal leased its chlorine manufacturing plant and mustard and Lewisite manufacturing facilities to the Colorado Fuel & Iron Chemical Co. (CF&I) and the Julius Hyman Chemical Co. The Hyman firm in 1950 assumed the lease of the CF&I company, and a year later, the Shell Chemical Co. purchased the Hyman lease and enlarged the Shell facilities for the manufacture of various types of insecticides.

Recent responses from the Hyman and CF&I firms, the report said, indicated that they kept no records of the quantities or types of liquid wastes expelled into Lake A.

In 1953 and 1954, the report said, the arsenal discharged into Lake A the neutralized and detoxified byproducts from the GB nerve gas manufacturing plant, along with plant washdown water. Byproducts and plant washdown water from the Shell plant also were discharged into this lake.

Lake A had no liner or membrane, according to Arthur Whitney, public information director at the arsenal.

The use of Lake A was discontinued in 1954 and was replaced with a new disposal pond, Lake F, constructed with an asphalt membrane on the bottom to prevent any seepage into the earth. This pond covers 100 acres and has a capacity of 250 million gallons, the report noted.

In 1962, the report continued, a deep disposal well was completed at the arsenal, and pumping of industrial wastes into this well was initiated. The use of this well was discontinued, and the well was capped in February 1966 after a correlation of the pumping and earthquakes in the area was shown.

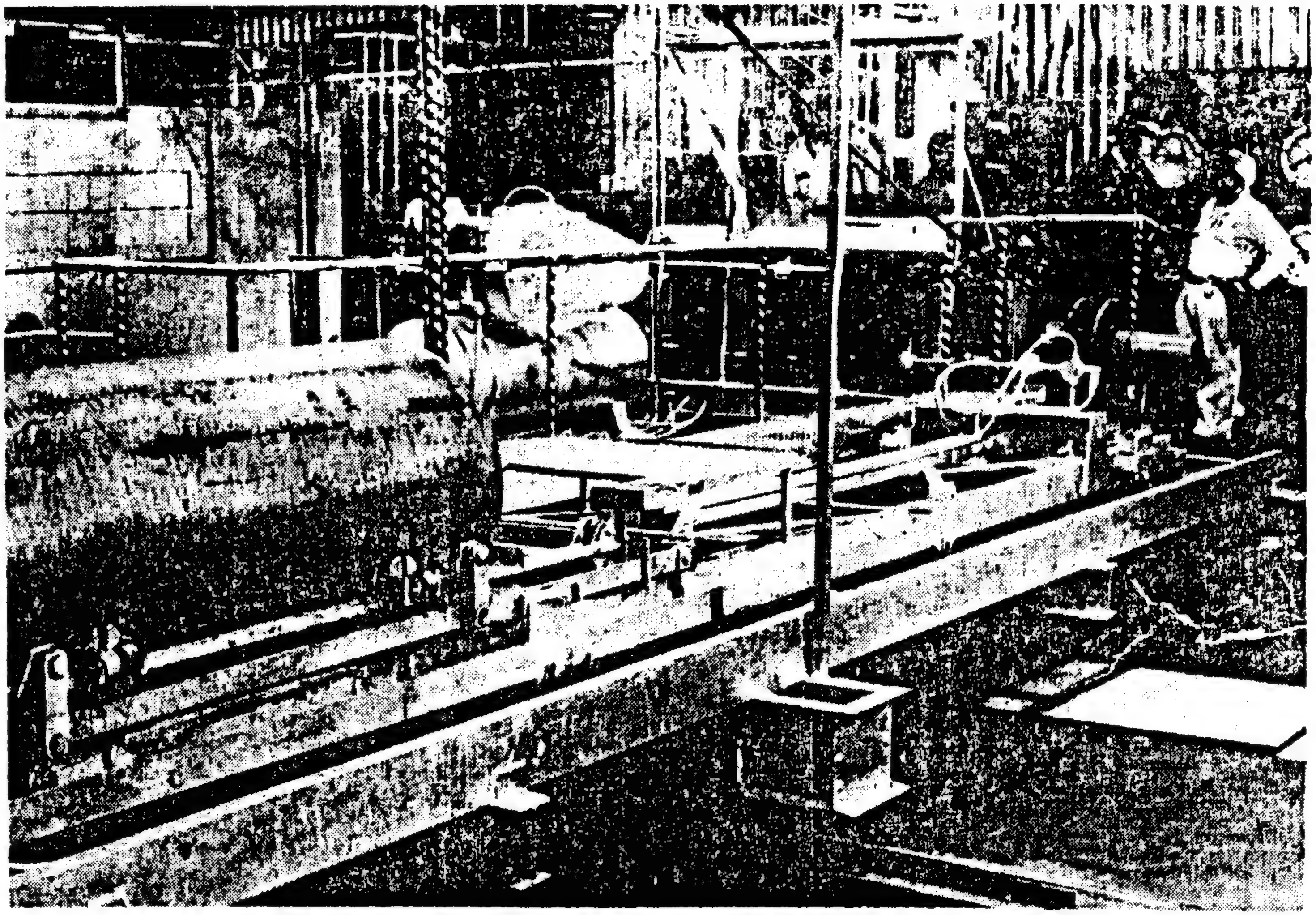
INTO LAKE

Since that time, neutralized plant washdown water from the GB nerve gas munitions filling operations. white phosphorous muniton filling operations and neutralized byproducts and washdown water from the Shell operation have been discharged to Lake F, the report said.

In destruction of anticrop agents, mustard gas and nerve gas agents, all federal and state emission standards have been met, the report said.

The facility for the destruction of the nerve gas agent has been designed so that no industrial waste water is expelled to Lake F.

A program directed toward over-all cleanup of arsenal buildings and grounds is under way, the report said.



NEWS PHOTO

Chemical containers readied for oven

The last of 3,407 containers that formerly held blistering mustard gas is readied for the oven Monday at Rocky Mountain Arsenal. The chemical agent was already removed and burned. The oven treatment was to burn residues possibly left in the 25-year-old, one-ton containers. Other chemical war agents still to be destroyed or sold for industrial use by 1976 include 2,250 tons of GB nerve gas as well as 21,115 obsolete M-34 nerve gas cluster bombs and 1,294 one-ton barrels of phosgene gas.

Rocky Mountain News 19 March 1974

FOURTH OF STOCK

Arsenal Burns Mustard Gas

About one quarter of the 3,408 mustard gas container stored at the Rocky Mountain Arsenal northeast of Denver since the 1940s has been detoxified, a spolesman at the arsenal said Wednesday.

Burning of the mustard gas, which was started late last August, will be completed in August 1974, according to Maj. Andrew Blasco, deputy commander at the arsenal.

Destruction of the 584,000 gallons of mustard gas originally was to have started in October 1970, but was delayed by the necessity to obtain environmental impact statements from federal and state agencies. Also, Blasco said, the initial system for the detoxification didn't work satisfactorily early in 1971, and a new system had to be designed.

The long-delayed disposal of 500,000 gallons of deadly GB nerve gas contained in 21,000 aerial cluster bombs stored at the arsenal is scheduled to begin in October and be completed in about three years, Blasco said.

There's no specific date set for the start of disposal of 1,294 containers of phosgene gas, another highly toxic chemical agent stored at the arsenal, Blasco said. Originally, this disposal was to have started after completion of the nerve gas disposal, which would be in 1976, Blasco noted. However, he said, the Army is exploring the possibility of simultaneous disposal of the two gases, but at different locations on the arsenal grounds.

Detoxification of the mustard gas, a highly irritating blistering agent, involves draining the gas from their one-ton containers and burning the gas in a furnace, Blasco explained. After burning, the gases resulting from the burning are "scrubbed" with sodium hydroxide, which takes gaseous impurities out of the air, he said.

This scrubbed air then goes into a device which settles out any particulate (iron oxide) in the form of a powder or dust which is collected and stored so it doesn't get into the air, Blasco said.

Blasco described the detoxification process as "a very controlled operation," in which safety is the overriding consideration. There have been no incidents in the burning of the mustard gas, he added.

As the detoxification progresses, the arsenal staff is working closely with officials of the Colorado Health Depart- at the arsenal on the detoxifica- ment who were briefed Tuesday tion system, Blasco said.

The last military use of mustard gas by the United States was during World War I, and the gas manufactured at the arsenal during the 1940s never has been used, Army officials have said.

The detoxification of the gases is in compliance with President Nixon's November 1969 edict requiring the destruction of all obsolete chemical-filled munitions and all biological warfare stockpiles, except those required for national defense research purposes, Blasco noted.

SECTION 10

MUSTARD PLANT LAYAWAY

10.1 GENERAL PLANT LAYAWAY OPERATIONS

Early in FY74 it became apparent that the Mustard demilitarization program would be completed ahead of schedule. In October 1973, the Program Manager, anticipating early completion, directed that the Mustard disposal plant be placed in layaway condition at the conclusion of Phase III. This was necessary since the plant would be used to decontaminate empty GB ton containers. Also it was possible that some equipment would be relocated to other facilities. To comply with the layaway directive, RMA prepared a "Plan and Cost Estimate for Site Cleanup and Equipment Layaway" in January 1974.[1] This plan presented detailed decontamination procedures and listed specific areas and equipment requiring decontamination.

As anticipated, Phase III of the Mustard demilitarization program was completed approximately four months ahead of schedule on 20 February 1974. However, 1200 gallons of mustard in 88 ton containers were still in stock for use in the Chemical Agent Munitions Disposal System (CAMDS) program. Although this precluded starting decontamination procedures, general site cleanup was started in the week of 4 March 1974. Following is a brief summary, by month, of the daily logs through completion of Plant layaway:

A. March 1974

On 7 March, the Plant Cleanup and layaway program was started by instituting general cleanup and painting procedures. On 15 March, the CAMDS program was officially completed, personnel strength dropped from 41 to 13, and decontamination procedures were started. For the remainder of the month, the mustard storage tanks were flushed with fuel oil and 83 ton containers of trash and contaminated material were burned.

B. April 1974

Flushing of the two mustard storage tanks with fuel oil was completed and the fuel oil-mustard mixture was burned. The storage tanks were then flushed with a supertropical bleach (STB) and water mixture for approximately one week. The water was spray dried. After flushing with STB, the tanks were drained to the central sump and the mixing units were removed and decontaminated by burning. In addition to the mustard storage tanks, the following equipment was cleaned and/or decontaminated:

1. Heat exchanger
2. Quench tower and scrubber duct
3. Brine storage tank (Building 538)
4. Dryer systems (Buildings 536 and 540)
5. Electrostatic precipitator
6. Unload booths washed

In the last week, both ton container furnaces were cleaned and repaired. Throughout the month, GB and CG contamination tests were run concurrently with plant cleanup and layaway procedures. Also, 68 ton containers of trash and contaminated material were burned.

C. 3 May 1974

The interior of both Building 537 storage tanks were painted with Rustoleum and the tank pit walls were cleaned and painted with Rustoleum. The sewers at Building 536 were flushed and approximately 10 ton containers of sludge from the sewer were removed and decontaminated by burning. Building 536 brine tank and the east scrubber system were cleaned. The vacuum system was cleaned and decontaminated with caustic. The mustard transfer lines, which were flushed in April, were removed, cut into small sections, and decontaminated by burning. Decontamination tests using GB filled munitions were conducted intermittently throughout the month.

Although Building 742 was not used for mustard demilitarization, it was contaminated during the manufacture of mustard filled munitions. Decontamination of metal from Building 742 was started in the third week of May with one-shift operation and increased to three-shift operation during the last week. In all, 107 ton containers of metal were decontaminated by burning and approximately 65 ton containers of trash were burned.

D. June 1974

Material from Building 742 continued to be decontaminated by burning throughout the month of June. A total of 79 ton containers were burned, 45 of metal, 26 of concrete, and 8 of trash. In addition, 51 ton containers of material from the facility were burned. This material consisted of protective clothing, carbon filters, air piping, ventilation duct, and trash. All floors and subfloor ventilation trenches were washed down and flushed with caustic and water. The east ton container furnace was shut down, cleaned, and repaired. The electrostatic precipitator was cleaned again and modified (under warranty) so that all five stages were in operating condition.

E. July 1974

The last ton container of contaminated metal from Building 742 and 6 ton containers of trash from the decontamination facility were burned in July. Although general cleaning and painting was accomplished throughout the facility, the major effort was expended on the unload booths. All four booths, the ton container carts, the scale pits, and drain systems were thoroughly washed and decontaminated. After decontamination by caustic wash and heating, the ton container carts were painted and all four booths were scraped and painted both inside and out.

10.2 SUMMARY

The Plant Cleanup and Layaway Program was considered completed in July, 1974. Although some areas and equipment were known to be contaminated (cement and buried piping and equipment), no further decontamination was performed. First, because the contamination presented negligible hazard to operating personnel, and secondly, because the procedures required were impractical (for concrete) or the contamination was inaccessible. Also, the plant was not placed in complete layaway condition since it was scheduled for use in the Phosgene Demilitarization program and plant modifications were scheduled to start within two months to support the Phosgene Program.

REFERENCES

[1] "Plan and Cost Estimate for Site Cleanup and Equipment Layaway", Rocky Mountain Arsenal, 4 Jan 1974.

APPENDIX A

1972 SYSTEM TEST SERIES

A.1 GENERAL

The test plans developed by the special process engineering team at Edgewood Arsenal were divided into six series as follows:

R Series - Incinerator/Reactor
D Series - Spray Dryer
F Series - Ton Container Burn
A Series - Bulk Mustard Burn
P Series - Electrostatic Precipitator
T Series - Preproduction Operations

The objectives, procedures, and conclusions of each test series are briefly described in the following paragraphs. For detailed test procedures and results, refer to Edgewood Arsenal Special Report, dated June 1974, Bulk Mustard Demilitarization at Rocky Mountain Arsenal, April 1969 through September 1972 – Lojek.

A.2 INCINERATOR/REACTOR TESTS (R SERIES)

The first series of tests (Runs R-1 through R-4) was conducted in December 1971, to evaluate reactor performance. The reactor was operated at variable temperatures with variable air flow rates, mustard feed rates and feed stock composition. These tests showed that mustard emission limits were controllable and that particulate emission limits were not. The second series of tests (Runs R-5 through R-9) was conducted in January and February 1972 to establish reactor temperature profiles and to evaluate scrubber performance. The reactor was operated at lower temperatures and the scrubber brine pH was varied. These tests showed that lower temperatures reduced particulate emissions but increased mustard emissions. Also, scrubber performance improved at lower brine pH. The third and fourth series of tests (Runs R-10 and R-11, R-12 through R-14) were conducted in February 1972 to evaluate performance of the wet electrostatic precipitator. The incinerator/reactor was operated under various parameters. The desired efficiency of 95 percent was never obtained so further testing was discontinued. However, these tests did determine an optimum feed stock composition and scrubber brine pH. At that point, a Worthington ionizer was installed and the reactor failsafe mechanism was modified. The last series of tests (Runs R-15 through R-17) was conducted to evaluate new and modified equipment. Again, the incinerator/reactor was operated under various parameters. Tests of the ionizer were inconclusive and the failsafe mechanism substantially reduced mustard emissions during process upsets.

A.3 SPRAY DRYER TESTS (D SERIES)

During the first R series of tests, excessive plastering was observed on the fluid bed and walls of the spray dryer. A lampshade device was installed on the nozzle to

counteract this effect. The first series of tests (Runs D-1 through D-5) was conducted in January 1972 to evaluate spray dryer modifications. During the tests, the nozzle location was changed. These tests showed that the plastering effect was reduced but not completely solved; consequently, further modifications were incorporated. A second series of tests (Runs D-6 through D-7) was conducted in February 1972 to evaluate equipment modification. These tests showed that the modifications were not completely effective and that the dryer could not even process 14 GPM of brine (design rate was 20 GPM). The final series of tests (Runs D-8A through D-8D) was conducted to optimize the brine feed rate. These tests established an optimum brine feed rate of 9 GPM which was sufficient for a mustard feed rate of 1 GPM.

A.4 TON CONTAINER BURN (F SERIES)

The ton container furnace was tested simultaneously with the reactor and spray dryer. The first series of tests (Runs F-1 through F-7) was conducted to establish the operating parameters required to effectively decontaminate emptied ton containers. The type and quantity of furnace air additions were varied during these runs. It was shown that burn time could be reduced by air lancing the ton containers. No relationship could be established between the ash mustard concentration and original residue weight. Also, the upper limit of residue could not be established since particulate emissions could not be correlated with residue weight and (as in R series tests) the particulate emissions exceeded standards. The second series of tests (Runs F-8 through F-11) was conducted to further establish operating parameters. Satisfactory ton container decontamination was obtained by increasing the scrubber exhaust air flow rate and by operating the furnace at 1000°F. Also, salt buildup was eliminated by maintaining brine specific gravity at 1.02. As a result of these tests, several equipment modifications were incorporated and a third series of tests (Runs F-12 and F-13) was conducted to evaluate these modifications. These tests showed the equipment modifications to be successful; however, an upper residue limit was still not established since the particulate emission standard could not be met. The final series of tests (Runs F-14 through F-17) was conducted to determine acceptable operating parameters. During these tests, operating techniques and equipment performance were emphasized. The particulate emissions were substantially reduced but they still exceeded emission standards. It was apparent that further equipment modifications/additions were required; thus, it was decided to use an electrostatic precipitator (dry) to eliminate the particulate emission problem.

A.5 BULK MUSTARD BURN (A SERIES)

The first series of tests (Runs A-1 through A-9) was conducted in April and May 1972, to determine the feasibility of burning liquid mustard in the ton container furnaces. Two methods of incineration were tried; first, liquid mustard was sprayed through two nozzles at varying rates; second, liquid mustard was pumped or dribbled into an open ton container in the furnace. Furnace temperature was maintained at less than 2100°F for both methods. Tests showed the spray method

to be preferable since higher feed rates could be achieved. However, particulate emission standards were still not achieved. The second series of tests (Run A-10) was conducted in May 1972 to obtain further data. The spray method was used in both furnaces and furnace temperature was maintained at less than 2000°F. Good combustion was obtained at a 2.0 GPM feed rate.

A.6 DRY ELECTROSTATIC PRECIPITATOR (P SERIES)

In May 1972, a pilot dry electrostatic precipitator was rented to study the effect of such a unit in reducing the Tailor System particulate emission. The first series of tests (Runs P-1 through P-3) was conducted in May 1972, to develop criteria which would permit design of a full scale unit. These tests showed that the precipitator could reduce particulate emissions and could operate with a minimum amount of maintenance. However, more testing was required to optimize operating temperatures. The pilot precipitator was relocated to the ton container furnaces and the second series of tests (Runs P-4 through P-9) was conducted in May and June 1972, to obtain additional design data. During this period, no operational difficulties were encountered and the continuous operation did not adversly effect the efficiency of particulate removal. This confirmed the results of these series of tests.

Other subsystem tests were conducted simultaneously with the precipitator tests to determine corrosion rates and scrubber flow rates. The most important conclusion of these tests was that an additional dryer system was required.

A.7 PREPRODUCTION OPERATIONS (T SERIES)

Two preproduction tests were conducted in June 1972. The first test (Run T-1) was conducted to ensure that the ton container furnace system was ready for the simultaneous incineration of liquid mustard and the decontamination of empty ton containers without exceeding emission standards. The results of stack sampling showed negligible SO_X emissions and very low levels of NO_X, acid mist, and total acidity. However, opacity readings of the plume from the 200-foot stack and the electrostatic precipitator were marginal. The second test (Run T-2) was conducted to demonstrate the reliability and safety of the mustard demilitarization system, to verify the Standing Operating Procedures, and to demonstrate compliance with emission standards. The result of this test was the recommendation by USAEHA that pilot production operation commence according to the revised detoxification plan.

APPENDIX B

FINAL PLANT CONFIGURATION DESCRIPTION

B.1 GENERAL

This Appendix describes the Mustard Disposal Facility prior to its last major modification (installation of the West Scrubber System, on or about 10 November 1972).

B.2 SITE DESCRIPTION

The disposal operation was performed in Buildings 522, 527, 536, 537, 538, and 540 which are located in the Plants Area (Figure B–1). The disposal area is 15,750 feet from the nearest public road and public railway. It is 10,000 feet from the nearest Arsenal boundary (south). Other facilities and activities adjacent to the disposal area include the commercial operations of Shell Company, Arsenal support facilities, and various tenant storage areas. This site location for mustard disposal was approved by USAMUCOM on 23 September 1969.

Six buildings in the Plants Area were utilized for the mustard disposal operations: Building 536 contained the Tailor mustard incinerator/scrubber/spray dryer system; Building 537 contained the thaw room, the container unloading equipment and the mustard storage and pumping equipment; Building 538 contained the bulk agent incinerator, the ton container decontamination furnaces and a maintenance shop; Building 540 contained the container cutting and ash scraping operation, the spray dryer controls, the salt compacting and barrelling operation; Building 522B contained the personnel change house and potential largescale decontamination station; and Building 527 was used as an emergency personnel decontamination station, a protective clothing issue point, and contained lavatory facilities. The general layout of these buildings and their relative location to each other are shown in Figure B–2.

The Plants Area was designated as a "Controlled Area" in accordance with Army Regulation AR-190-3. The Plants Area was enclosed with a security fence and guarded or locked gates in accordance with applicable Security and Surety Regulations. The security fence contained a personnel/vehicle entry gate; two additional vehicle entry gates; and two railroad access gates.

B.3 DEMILITARIZATION PROCESS FACILITIES DESCRIPTION

B.3.1 BUILDING 522B - PERSONNEL CHANGE HOUSE

This building is used as the change house for the personnel of the Mustard Demil Program. The building is interconnected with Building 522 and 541. Building 522B is constructed of concrete foundation and floors and concrete block walls, steel supported gypsum, rigid insulation, and a 5-ply built-up roofing. The building has

two administrative offices, two large change rooms, and rest rooms and showers. Additionally, it has a supply room (primarily for clothing issue) which is readily adaptable to this program's requirement without major alterations. The building is located south and slightly west of Building 538 and is the nearest facility to the Mustard Plant suitable for use as a change house.

B.3.2 BUILDING 527 - EMERGENCY CHANGE HOUSE

This building is a quonset hut located approximately 150 feet south of Building 538. The building plan and location are shown in Figure B–3. This is an all-steel building 20 feet wide and 48 feet 5 inches long, set on concrete footings and floor. The building is wired for electric lighting only. An emergency change room and shower have been added to this building (as shown on the drawing) which are isolated from the out-of-area lavatory facilities. A temporary house trailer is located adjacent to Building 527 to provide a rest break and lunch room area. The quonset hut also contains a supply room for clothing and protective equipment issue. The building is primarily used as a change room for the M3 (complete rubber) suits.

B.3.3 BUILDING 536 - TAILOR SYSTEM

Although originally designed for the storage of crude H mustard, this building has been used in the past for the storage of acid and caustic. It also was used in 1971 to house the Tailor mustard incinerator/scrubber/spray dryer system for the original detoxification program. The building is of cinder block construction, painted to make it impervious to moisture, with the exception of the south wall which has a removable siding. The removable sidewall construction is provided so that tankage and equipment can be moved readily in and out of the building. There is a total of 4,000 square feet of floor space in the building; however, there are two ceiling elevations in the building, one section about 15 feet high and the other section 26 feet high. The floor space is approximately the same in both areas, i.e., 2,000 square feet each. Only one large storage tank (20,000 gallons) on the east side of the building remains as part of the previously installed storage equipment. This tank was used to store 50 percent caustic solution and was located inside the heated building to avoid freezing. A control room is located in the southwest corner. The Tailor system is shown (in schematic form) in Figure B–4. Since the system did not meet expectations as a practical Mustard Disposal System and was abandoned in mid-1972, much of the instrumentation, heat exchangers, fans, monitoring equipment, tanks and pumps were used to upgrade the remainder of the plant. The only portion which remains in its original configuration is the spray dryer and its related equipment. This dryer was used to spray dry scrubber brine until the Bowen Spray dryer became operational. It was also used to pilot the compacting operation. The Tailor spray dryer is capable of drying 10 to 12 gallons per minute of brine feed with proper weekly cleanout and maintenance. It has a bag house to collect the salts, which proved very efficient with no opacity problems. The building has floor drainage to the liquid waste collection system (sump). All of the decontaminated liquid wastes from Buildings 536, 537, 538, and 540 are collected in the liquid wastes sump near the northeast corner of Building 536 and are subsequently transferred either to the brine storage tanks for spray drying or to the chemical sewer system.

B.3.4 BUILDING 537 - BULK MUSTARD DRAINING, STORING AND PUMPING

This building was known as the "thaw house". It is also constructed of cinder block coated to prevent absorption, and has about 16,000 square feet floor space. It has a painted concrete floor. It was used with very little alteration. The unloading dock is located at the southwest corner of the building where the mustard containers from the toxic storage yard were unloaded from the modified transport trucks. An overhead monorail crane was used for transferring the containers from the truck to the center thaw room (the only one of the three thaw rooms that was used during the program for the thawing operation). The center thaw room is approximately 140 feet long (east/west axis) by 20 feet wide by 14 feet high and has a capacity of 100 containers. The building has a series of bridge cranes that allow the ton containers to be moved to any part of the building. Overhead rolling doors at each end of the thaw room allowed the room to be closed off to contain the heat. The ventilating system picked up air through the grates in the concrete exhaust duct in the floor and exhausted the air via a fan and charcoal filters to the atmosphere. Slight negative pressure was thus maintained in the thaw room. Heat was provided by circulating a pre-set portion of the ventilating air stream over steam coils located in the roof plenum chamber. A thermostatically controlled room temperature of 90° to 140°F could thus be maintained. The normal division of the air stream was set at 10 percent exhaust to the atmosphere and 90 percent recirculation. However, in the event of a spill the system was immediately put on emergency ventilation which routed 100 percent of the ventilating stream to the filters; thereby, rapidly reducing the room temperature to ambient and increasing the comfort of personnel in protective clothing who must enter the room to decontaminate. The room was equipped with drainage to the liquid waste sewer. An adjustable dam was installed in the drainage ditch to contain liquid wastes and spills until they could be decontaminated prior to release to the common sump.

The east end of Building 537 contains the three original mustard unloading booths and one second-generation booth installed in August 1973. In these booths, warmed ton containers from the thaw room were drained of mustard by vacuum. The three older model unloading booths were modifications of the booths originally installed in the building. Each of these booths contained a platform scale for weighing the containers. The agent container rested on a hydraulically powered unload cart which had the capability of moving the container into and out of the booth, rotating it 360° either clockwise or counterclockwise, and tilting either end. The booth door was an integral part of the cart. Both cart and door rested on the platform scale when they were fully inserted into the booth. The operators worked through glove ports on the booth door. The butyl rubber gloves in the glove ports were changed once per day during unloading operations. Protective clothing specified by SOP for operator use consisted of "congo red" treated coveralls, a mask with hood, rubber apron and "congo red" treated gloves. Section 5 of this report provides a description of the "congo red" treated clothing. The ton container was unloaded through two high pressure, fiber reinforced, butyl rubber hoses connected to its valves; these hoses were changed every two weeks. The unloading procedure is contained in the Mustard SOP. Each booth was valved for compressed air and container venting (to the ventilation trench). In addition, all booths were equipped with pressurized DS_2 decontaminant supply and process water for decontamination and wash-down.

The second generation booth (number 1A) was designed at RMA based on safety recommendations resulting from a design defect in the original three booths. The primary difference between the two types of booth was that on Booth 1A the operator worked through glove ports located at the opposite end of the booth from the door, thereby decreasing the risk of exposure and eliminating the need for rubber protective clothing. The door was a guillotine type with an inflatable rubber seal as opposed to the movable, baffle-type seal on the other booth doors. The inflation mechanism for the seal was interlocked with the booth lighting to prevent unloading operations when the door was not sealed. An additional improvement was the use of load cells built into the unload cart. The load cells replaced the platform scale and made the sealable door possible since the door became a separate piece of equipment not connected to the cart and scale as in the other model booth. The draining capability of the booth was improved by increasing the diameter of the agent piping between the booth valving manifold to the storage tanks. The effectiveness of Booth 1A was excellent. All of the booths were continually kept under negative pressure, via a concrete ventilation duct, by a ventilating fan outside the building. This ventilation system was equipped with particulate and charcoal filters similar to those used in the thaw room ventilation system. The concrete duct also served as a dump for the booths, which contained a dam, to allow wash water to be sampled and decontaminated, before being dumped to the central sump.

Located beneath and to the rear of the booths were two horizontal 2600-gallon tanks (designated as the East and West Tanks) for receiving mustard from the ton containers. Normally, the West Tank was used as the drained agent receptable and its contents were periodically transferred by vacuum to the East Tank for pumping to the incinerator. Positioned over the mustard storage tanks were the two mustard transfer pumps to transfer the incinerator feed. The West Tank was equipped with a submerged centrifugal pump which was installed in 1972 to replace the previously installed Moyno positive displacement pump. The submerged centrifugal pump's operating life under maximum operating conditions was as short as three weeks and as long as three months; the operating duration was strongly dependent on the type of failure which occurred. The East Tank was equipped with the original Moyno positive displacement pump. While not entirely suitable for this application, the Moyno pump did have the advantage of being easily changed. Additionally, it had the capability, due to its suction head (negative pressure) operation, of pumping fuel oil to the furnaces from an outside storage tank while insuring that no mustard could inadvertently be pumped to the oil tank. The two pumps and tanks were interconnected so that either pump could supply the furnaces while the other was recirculating the tank contents or being used to transfer contents from one tank to the other. The tanks were also interconnected by the vacuum system for the purpose of transferring agent from tank to tank by vacuum.

The vacuum pumps provided negative pressure to the tanks for the unloading operation. The negative tank pressure was used to draw the agent from the ton container in the unload booth. The dropout pot or condensate collection vessel was a glass lined tank of approximately 100 gallon capacity located in the vacuum line between the storage tanks and the vacuum pumps. This piece of equipment plus a

"U" shaped riser approximately 40 feet in height precluded gross contamination of the vacuum pumps. These pumps (Nash Hytor) had a water seal. The water was actually a dilute caustic solution of pH 11 to 14. This slight amount of caustic was used to prevent the seal water from becoming acid due to mustard vapor hydrolysis.

Both tanks were equipped with sight glasses which were read every hour during bulk incineration. The tank drainage thus measured (which was somewhat inaccurate due to the viscosity of the agent), provided the only reliable method of determining the incineration rate at the furnace.

Both tanks were equipped with a homogenizer intended to grind up the solid sulphur particles. These homogenizers were of limited value, particularly after the strategy of emptying ton containers into one tank, allowing it to settle, and then transferring by vacuum to the other tank was adopted.

The tank pit was ventilated directly to the bulk incinerator via a 24-inch dampered circular duct. The pit environment was maintained at approximately 90°F by a forced air heater in order to maintain the mustard in the tanks fluid. Drainage in the unloading area also went to the liquid waste sewer.

B.3.5 BUILDING 538 - BULK AGENT INCINERATION AND TON CONTAINER DECONTAMINATION

Building 538 is a steel frame building with corrugated asbestos siding. The building housed the bulk agent incinerator, the two ton container decontamination furnaces and a small maintenance shop (see Figure B–2).

A. Bulk Agent Incineration

The bulk agent incinerator (hydrazine furnace) was a horizontal barrel-type furnace which was originally constructed for incinerating contaminated liquid hydrazine (Figure B–5).

The furnace was modified in January and February 1973 to be suitable for burning bulk agent. It was inserted on line during March 1973 and thereafter assumed the role of the west ton container furnace which had up until that time been used to incinerate the bulk agent.

The furnace was fed by the mustard pumps as described previously. The agent was carried at 60 to 80 PSIG pressure in the inner pipe of a double-walled line. The annulus was filled with circulating, hot (90°F) ethylene glycol, both to help keep the mustard hot and fluid, and to aid in detecting leaks in the inner pipe. The mustard feed passed through an air-operated, quick-acting, on-off solenoid valve (interlocked with the control panel) and an air-operated, manually-controlled regulating valve. The agent spray nozzle was an oil nozzle manufactured by John Zink, Co. Atomizing air was introduced into the agent prior to the mustard leaving the nozzle through ten, radial, 1/8-inch orifices. The orifices were angled at approximately 60° from the horizontal thus

providing a conical agent spray pattern. A ring gas burner surrounded the nozzle. This burner could supply heat to the furnace for warmup or idling but was normally cut back to little more than a pilot flame during operation since the mustard agent flame was self-sustaining and the burn rate was highly dependent upon maximum furnace temperature limits.

Both the agent nozzle and ring gas burner were located in the combustion chamber, which was a cylindrical, brick lined chamber situated immediately next to the furnace, entered the furnace axially through the nozzle end of the combustion chamber. Dilution air entered the furnace through several small adjustable ports located on the front face of the furnace barrel.

Combustion products exiting the furnace entered a brick lined common breeching, south of and above the furnace. The hot gases then passed to one or both of the quenching tanks which are described in paragraph B.3.6. The combustion products were carbon dioxide, water vapor, sulfur dioxide and trioxide, hydrogen chloride and a varying amount of iron oxide particulate along with unburned carbon (soot).

Operating conditions and production rates of the bulk incinerator are detailed in Section 5 of this report.

B. Ton Container Decontamination Furnaces

Immediately adjacent to the bulk incinerator are the two ton container furnaces (East and West). These furnaces were constructed in 1944 for the purpose of decontaminating 55 gallon drums of mustard agent.

The furnaces are long, rectangular-arched, fireboxes with their long axis oriented north to south (see Figure B–6). The air-operated guillotine type doors were located on the north end. The flue for each furnace was positioned above the firebox with its opening immediately behind and above the door. The south end of each flue joined the central hot gas breeching.

The west furnace had eight Maxon natural gas burners placed as in Figure B–6. The east furnace had fourteen of the same type burners also shown in Figure B–6.

The drained ton containers were stored temporarily at the Building 538 storage yard, east of the building. The containers to be burned contained a residue heel averaging approximately 100 pounds for the HD and 600 pounds for the H type of mustard. Each container was brought to the weighing station in Building 538 where its serial number and Quality Assurance data were recorded. (See Section 6 for record keeping procedures). The ton container gross weight was also recorded at this time. The container was placed on an electrically-driven charging cart which was then positioned under the punching station at the door of either furnace. The container was punched at both ends on the top centerline. The punch consisted of an hydraulic ram with a wedge shaped hardened steel head. The furnace door remained open during punching

operations in order to utilize the furnace draft to remove any fumes from the punching operation. In addition the punch head was surrounded by a metal shroud which descended with the punch and sealed (by means of a rubber gasket) onto the container. The shroud was vented to the furnace flue by means of a stovepipe duct.

Incineration of the container took place in the south end of the furnace (see Figure B–6). Furnace temperature, burner configuration, furnace stay time and location of the ton container in the furnace were all matters of considerable study throughout the program; furnace conditions are discussed in Section 5 of this report.

B.3.6 BUILDING 538 ANNEXES - SCRUBBER SYSTEM

Immediately south of Building 538 are two annexes, southeast and southwest, housing the East and West Quench/Scrubber Systems respectively. The location and physical arrangement of these systems is shown in Figure B–2.

A. East Quench/Scrubber System

The East Quench/Scrubber System is the older of the two scrubber systems. It was installed in 1971 to serve as the air pollution abatement system for the ton container decontamination furnaces.

(1) East Quench Tank

The East Quench Tank is an upright cylindrical vessel 6 feet in diameter and 9-feet-3/4-inch tall with flat top and bottom plates. The material of construction is 1/4-inch Hastelloy B plate. The hot flue gases entered the top center of the tank through a 4-foot (OD) circular duct lined with 3-1/2 inches of castable refractory material. This circular duct carried the hot flue gases from the common furnace breeching to the quench tank. The tank is equipped with four horizontal rings of sprays. Each ring has eight spray nozzles. The normal quenching medium was scrubber bottom brine drawn from the Building 538 brine storage tank (see Figure B–7). Process water could also be added to any or all of the rings. A caustic supply connection was also present to insert additional caustic to the quench brine if required. The brine exited from the tank via a 6-inch Hastelloy pipe emerging from the bottom center of the tank and gravity fed into the scrubber bottom. The quenched flue gas exited the quench tank by means of a 26-3/4-inch (ID) rolled Hastelloy B duct. This Hastelloy duct is equipped with ten spray nozzles which operated from the same brine manifold as the quench tank spray. These nozzles could also be supplied with water when required. The nozzles were installed to further cool the flue gas leaving the quench tank. The four rings of nozzles alone did not prove adequate for quenching to the desired scrubber inlet temperature. The quench tank operation is discussed in more detail in Section 5 of this report.

(2) East Scrubbing Tower

The East Scrubbing Tower is an upright cylindrical vessel 8 feet in outside diameter and approximately 31 feet tall. The shell was made from 7/8-inch carbon steel. The scrubber is a countercurrent packed tower caustic scrubber. Its purpose was to remove the pollutant products, HCl and SO_2/SO_3, from the flue gas stream prior to discharge to the atmosphere. The tower packing was a dumped packing consisting of approximately 9 feet of 1-inch by 1-inch pyrex glass Raschig rings which rested on a Hastelloy B support plate located 6-feet-7-inch from the baseplate of the vessel. The quenched flue gas entered the scrubber bottom just beneath the packing support plate. The gas stream passed upward through the packing where it became intimately mixed with the caustic scrubbing solution flowing down through the packing causing a chemical reaction between the pollutants and the caustic, and resulting in removal of most of the former from the gas stream. The caustic scrubbing solution (brine) consisted of scrubber bottoms which had been passed through a series of three heat exchangers and returned to the top of the packing via a distributor plate. Makeup caustic was added to this recirculating brine stream at the suction side of the recirculation pump. The pH of this solution was controlled manually (on the east scrubber only) at a predetermined value. Periodic samples were drawn from the recirculation line, tested for pH by indicating paper and for specific gravity by a float hydrometer, and then sent to the QA Laboratory for other analyses. The specific gravity of the solution was similarly controlled by addition of process water via the spray nozzles on the quench tank.

The input to the scrubber bottom from the Quench tank was allowed to accumulate to a maximum depth at which a level switch activated a discharge pump, draining the scrubber bottom to pre-set and automatically controlled minimum depth. This discharge brine was pumped to a 20,000 gallon holding tank from which it was drawn to supply the quench and to feed the spray dryer.

The brine typically consisted of the sodium salts of the carbonate, bicarbonate, chlorine, sulfate and sulfite ions in varying proportions depending on the process rate and operating conditions at any specific time. The brine also contained approximately one percent by weight suspended particulate in the form of various iron oxides. In addition the brine sent to the top of the scrubber contained enough caustic (sodium hydroxide) to yield the desired operating pH.

The scrubber was originally equipped with a York stainless steel wire mesh mist eliminator which was removed in May 1973 after they proved unsatisfactory, primarily because of plugging. The rest of the program was finished without a mist eliminator in the scrubber. The scrubbed flue gas exited the top center of the scrubber and was drawn toward the electrostatic precipitator via a 30-inch (OD) mild steel duct.

B. West Quench/Scrubber System

The West Quench/Scrubber System was constructed during the summer and early fall of 1973. Construction, except for the winterizing enclosure, was complete at the end of October 1973. The system was designed and built at RMA based on the requirement for additional scrubber capacity to support the second and third phases of the demil program which entailed higher production rates than those experienced during Phase One. The west system was identical to the East Quench/Scrubber in principle of operation. The two systems differed, however, in details of construction and instrumentation representing second generation improvements (Figure B–8).

(1) West Quench Tank

The West Quench Tank is similar to the East Quench Tank with the exception of the following:

a. The West Quench configuration differs from the East Quench primarily by the addition of a domed top and bottom.

b. Five rings of eight nozzles per ring are utilized as opposed to the four rings previously used on the East Quench. These five rings proved adequate to maintain the quench outlet temperature at the desired point. Water could be added to either the top ring of nozzles or all nozzles but not to each ring individually. This arrangement was adequate in that emergency cooling could be achieved with all nozzles switched to water if the quench brine pump pressure was lost for some reason.

c. The addition of caustic to the quench tank was by means of a supply line and conical spray nozzle installed in the side of the vessel itself rather than tapped into the brine supply line. The caustic flow was controlled by an automatic pH sensor/controller operating on the quench exit brine. This system was not used during the program since its primary functions were to aid the scrubber in pollutant removal from the gas stream and to maintain the required caustic level in the scrubber brine. In operation, however, the scrubber caustic makeup system did not require the assistance of the quench caustic system.

d. The West Quench Tank outlet represented an improvement over the design of the East Quench Tank in that the gas and brine exits were combined into one 30-inch ID Hastelloy B duct exiting from the domed bottom of the West Quench Tank rather than the side as in the East Quench Tank. No sprays were incorporated in this duct due to the improved efficiency of the tank.

(2) West Scrubbing Tower

a. The West Scrubbing Tower is identical in function to the East Scrubbing Tower. The dimensions of this tower are 9-feet-10-inches

O.D. and 29-feet-3-inches in height. The tower is approximately 2 feet larger in diameter than the east scrubber but of approximately the same height. The packing consists of nine feet of 1-inch-by-1-inch pyrex glass Raschig rings topped by one-and-one-half feet of 1-1/2-inch by 1-1/2-inch ceramic Raschig rings. The packing support and brine distribution system are enlarged versions of those used in the east scrubber. One significant change from the east scrubber was the caustic control system. The system on the west scrubber was to utilize an automatic pH sensor/controller which sampled the scrubbing brine just beneath the packing. Makeup caustic, if any, was added to the brine recirculating line at the point where the line entered the top of the tower as opposed to the pump inlet on the east system. This system due to nondelivery of parts, was not operational until March 1974. Therefore, manual control was used and proved to be an adequate substitute during operations.

b. The west scrubber bottom discharge operated in the same manner as the discharge on the east system.

c. The west scrubber was equipped with a single heat exchanger cannibalized from the Tailor System equipment.

d. The scrubbed flue gas from the west scrubber exited via a 30-inch (OD) mild steel duct.

B.3.7 ELECTROSTATIC PRECIPITATOR (ESP)

A. Scrubber Control Dampers

The two 30-inch scrubber gas outlet ducts meet at a "Y" shaped duct section just upstream of the ESP inlet (see Figure B–2). Built into each arm of the "Y" is one control damper designed and fabricated at RMA. The dampers are constructed of mild steel and can be locked into selected positions. Use of these dampers enabled the scrubber systems to be used independently or in parallel by setting the appropriate control damper. Each damper section is equipped with a sealant packed slip joint to allow for expansion and contraction of the long runs of scrubber gas exit duct. Sampling points for velocity traverses and air monitoring test equipment are provided a short distance upstream of the damper sections on each duct. In addition, since this "Y" joint is elevated approximately 50 feet, a large, free standing, work platform was constructed to facilitate flue gas sampling and preheater maintenance.

B. ESP Preheater

A natural gas fired preheater burner is installed at the base of the "Y" section and is positioned so that the flame of the unit is oriented down the vertical section of the ESP inlet duct (see Figure B–9). The preheater supply unit incorporating air and gas controls, mixing section, pilot gas system, ignition

equipment and a flame detector with alarm are installed in a small prefabricated shed placed on the roof of the Building 538 southeast annex, next to the East Scrubber Tower. The air/gas ratio was adjusted manually to maintain the desired ESP inlet temperature. This preheater served as an after burner and mist eliminator. The flue gas exiting the scrubber passed through the flame of the preheater causing incineration of any fuel or agent which may have passed, unabsorbed, through the scrubbers. In addition, due to the lack of mist eliminators in the scrubber and the fact that the scrubber exit gas was water saturated the preheater was employed to dry the flue gas stream prior to its entry into the ESP. The preheater was sufficiently upstream to allow evaporation of any entrained moisture or condensate.

C. Electrostatic Precipitator (ESP)

The Electrostatic Precipitator (ESP) Model No. 09-1510-5, was manufactured by Precipitair Pollution Control, Longview, Texas, to design specifications originated by the Army. The unit consists of five stages arranged in series. Each stage is electrically independent of the others, thus allowing flexibility in selecting stages to be operated. The ESP was utilized to remove particulate matter from the flue gas stream, after it had been scrubbed prior to exhaust to the atmosphere. The principle of creating a charge on the particulate matter and then collecting it on oppositely charged collection surfaces was used in each of the five stages. The material collected was primarily iron oxide and soot, with a significant percentage of solubles collected as dried salt particles. The ESP residue was removed weekly from the collection hopper on each stage. The material was placed in 55 gallon drums, weighed, dated and sent to a warehouse for retention pending disposal by dry land dilution on arsenal property.

The ESP was tested for acceptance by the U.S. Army Environmental Hygiene Agency in August 1973. The unit met the applicable Colorado emission standards with three of the five stages operating.

D. System Driving Fan

The system driving fan was fabricated by Buffalo Forge Company, Buffalo, New York, Type 75R-SWSI. This fan supplied the draft for the entire mustard disposal system and exhausted and scrubbed dust cleaned flue gas to the atmosphere via a 55-foot insulated stack. The stack was insulated to prevent condensation.

B.3.8 STACK GAS MONITORING STATION

As a result of the requirements placed on the Mustard Disposal System to meet agent and SO_2 emission criteria, the facility is equipped with a monitoring station designed by the RMA Quality Assurance Office. This station is self-contained and houses instrumentation to monitor high and low mustard concentrations in the stack gas as well as sulfur dioxide. The low level mustard monitor consists of a glass beaded absorption bubbler with dibutylphthalate solvent. The bubbler was kept at a low temperature in a constant temperature bath. Bubblers were run for periods of

time determined by the Chief of QA dependent on the operational situation. Analysis of the bubbler contents for mustard agent was performed in the main QA Laboratory. The high level mustard monitor consists of two automatic sampling Tracor gas chromatographs set up in parallel. Considerable modification of the sampling lines was required to enable the instruments to sample the mustard without interference from sulfur dioxide or trioxide in the stack gas. Sulfur dioxide was monitored with a Dynascience Corporation continuous SO_2 detection instrument reading out directly in ppm. Heated probes for all instruments were inserted into the ESP exhaust stack for sampling.

B.3.9 BUILDING 540 - TON CONTAINER CUT AND SCRAPE OPERATION, BOWEN SPRAY DRYER

A. Ton Container Cut and Scrape Operation

After incineration the ton containers were allowed to cool to ambient temperature. At this time the containers were either certified agent free by Quality Assurance Inspection personnel or returned to rotation for incineration as re-burns if agent was found to be present.

Agent-free containers were brought into Building 540 where they were placed on their sides on the T.C. cutting platform. The T.C. cutting platform is a piece of equipment designed and built at RMA. It incorporates four rollers on which the T.C. rests; the rollers on one side of the container are connected to a variable speed electric drive which rotates the container on its longitudinal axis in either direction. The container was cut in half along its circumference by a fixed position oxy-acetylene torch fed from a bottled gas manifold outside the building. The container halves were removed one at a time from the cutting platform and taken to the ash barrelling station. The dust and fumes generated by the operation were removed from the work area by the exhaust action of a paint booth with a shroud extension to partially enclose the T.C. cutting platform. The ash residue (primarily iron carbide, oxides and sulfur) remaining after agent incineration was removed by manual scraping with hoe-like tools locally fabricated and shaped to the container's curvature. The ash was placed in used 55 gallon drums. A sample of the ash from each container was taken and analyzed in the QA Laboratory for agent. The serial number of each container was recorded and a lot number assigned to each drum of material (approximately four to five T.C.'s per drum). The drums were palletized and held with the T.C. halves for 48 hours (pending laboratory verification that they were free of agent), and trucked to a warehouse for storage to await ultimate disposal by dry-land dilution on Arsenal property. The ton container halves were hauled to the Property Disposal Yard where they were sold as scrap, under a contract arrangement.

B. Bowen Spray Dryer

The Bowen Spray Dryer was designed and constructed by Bowen Engineering Inc., North Branch, New Jersey. The unit was used to spray dry the brine resulting from the scrubbing operation previously described. The principle of operation

involved atomizing the brine feed in a hot gas environment, collecting the product, compacting and barrelling the product, and removing the fine particulates from the gas stream prior to exhaust to the atmosphere. Atomization occurred via a Bowen Spray Machine which utilized a horizontal spinning disc onto which the brine was fed. An air heater system, gas or oil fired, provided the 800°F to 1150°F inlet air to the drying chamber. This drying chamber was an inverted cylindrical-conical chamber, 24 feet in diameter. Dried product and hot air were extracted from the bottom of the chamber at 275°F and passed through cyclone separators which removed the majority of the product from the air stream. Fines were removed from the gas stream by a venturi scrubber and wet cyclonic scrubber in series downstream of the main fan. The main fan was driven by a 500 HP motor and maintained the system to the fan under a negative pressure. The volume of air was 40,000 CFM, the system pressure drop was approximately 40 inches of water. The air from the dryer is exhausted into the atmosphere, saturated at approximately 150°F. Product removed from the cyclone was fed to a compactor and drumming station where the salt was placed in 55 gallon drums, sealed, weighed, dated and palletized. The pallets of drums were placed in a warehouse pending final disposition instructions.

C. Standard Operating Procedures

The operations described above are completely detailed in the Standard Operating Procedures for the Mustard Operation (Ref. SMURM-0-P-62). There are also supporting SOP's such as the toxic yard SOP (Ref. SMURM-L-S-SD-7-70) to support Mustard Operations.

D. Protective Clothing and Specialized Equipment

Protective clothing and specialized equipment for each operation, together with first aid, accident reporting instructions, foreman's responsibilities, etc., are contained in the SOP's.

E. Technical Data Package

There is a complete technical data package for the mustard facility. Ref. "Tech Data Package - List of Drawings" dated 14 May 1975.

F. Process Equipment Description

There is a listing of Process Equipment. Ref. "Part 1: Process Description, Equipment Specifications, Drawing Catelog" of "Mustard Disposal Program - Project Eagle I, Technical Data Package" dated 1 July 1974.

G. Maintenance Manuals

There is a Preventive Maintenance Manual, Ref. "Rocky Mountain Arsenal Preventive Maintenance Program DEMIL Hand HD, Contract No. DA AA05-73-C-0013".

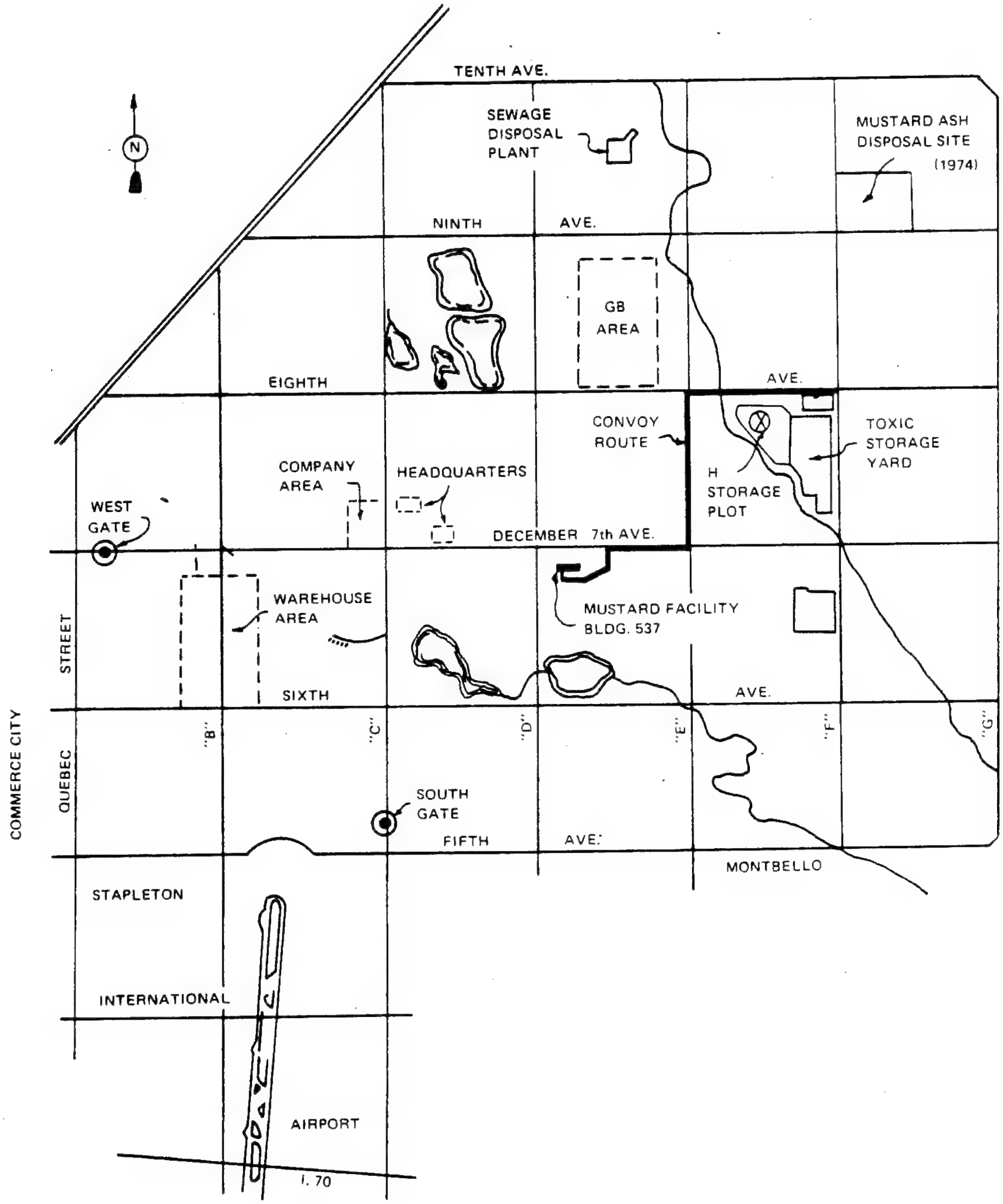


FIGURE B–1. PLANT AREA GENERAL ARRANGEMENT OF ROCKY MOUNTAIN ARSENAL

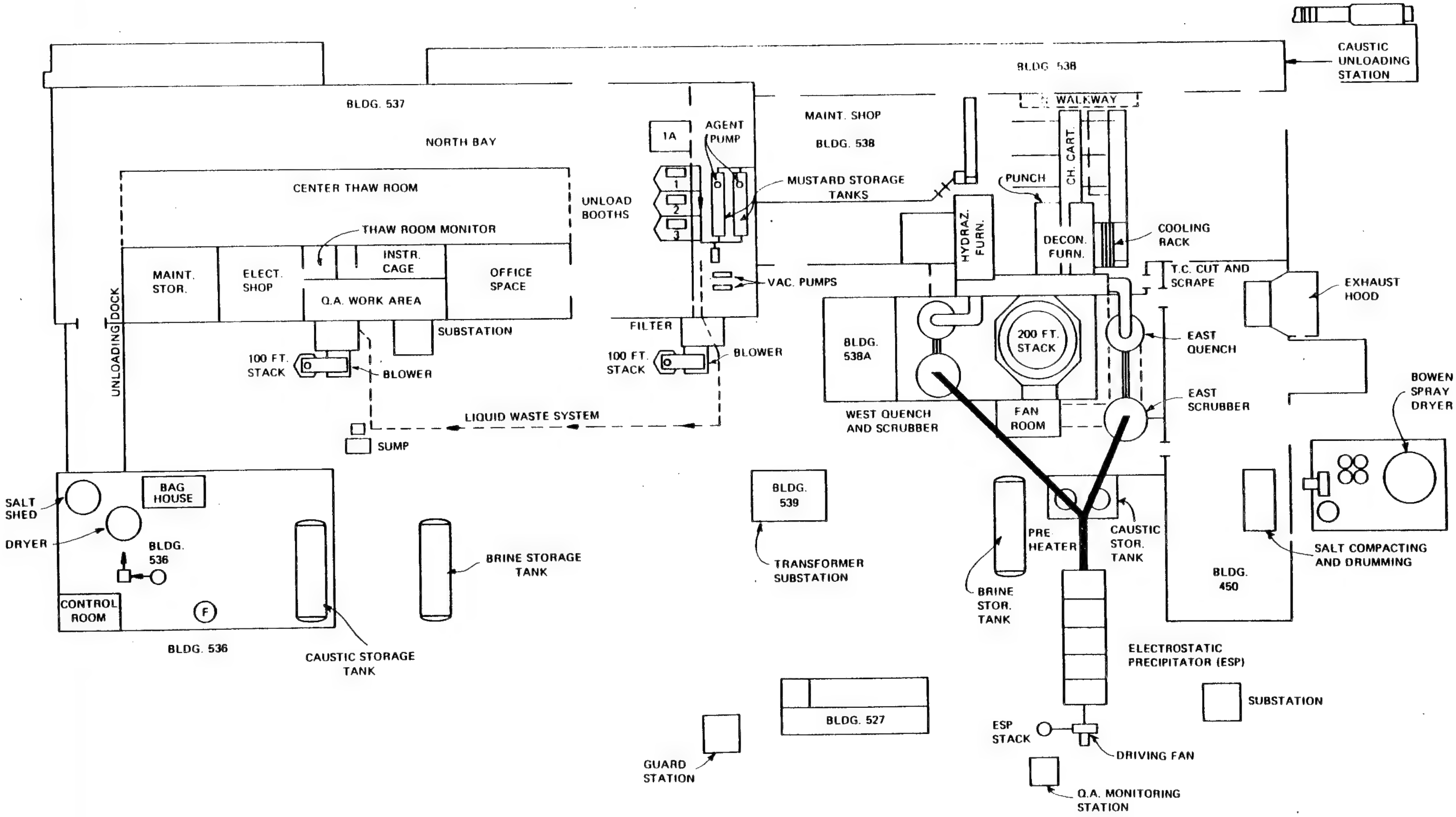


FIGURE B–2 PLANT LAYOUT - MUSTARD DISPOSAL FACILITY, ROCKY MOUNTAIN ARSENAL - AS OF 1 NOV

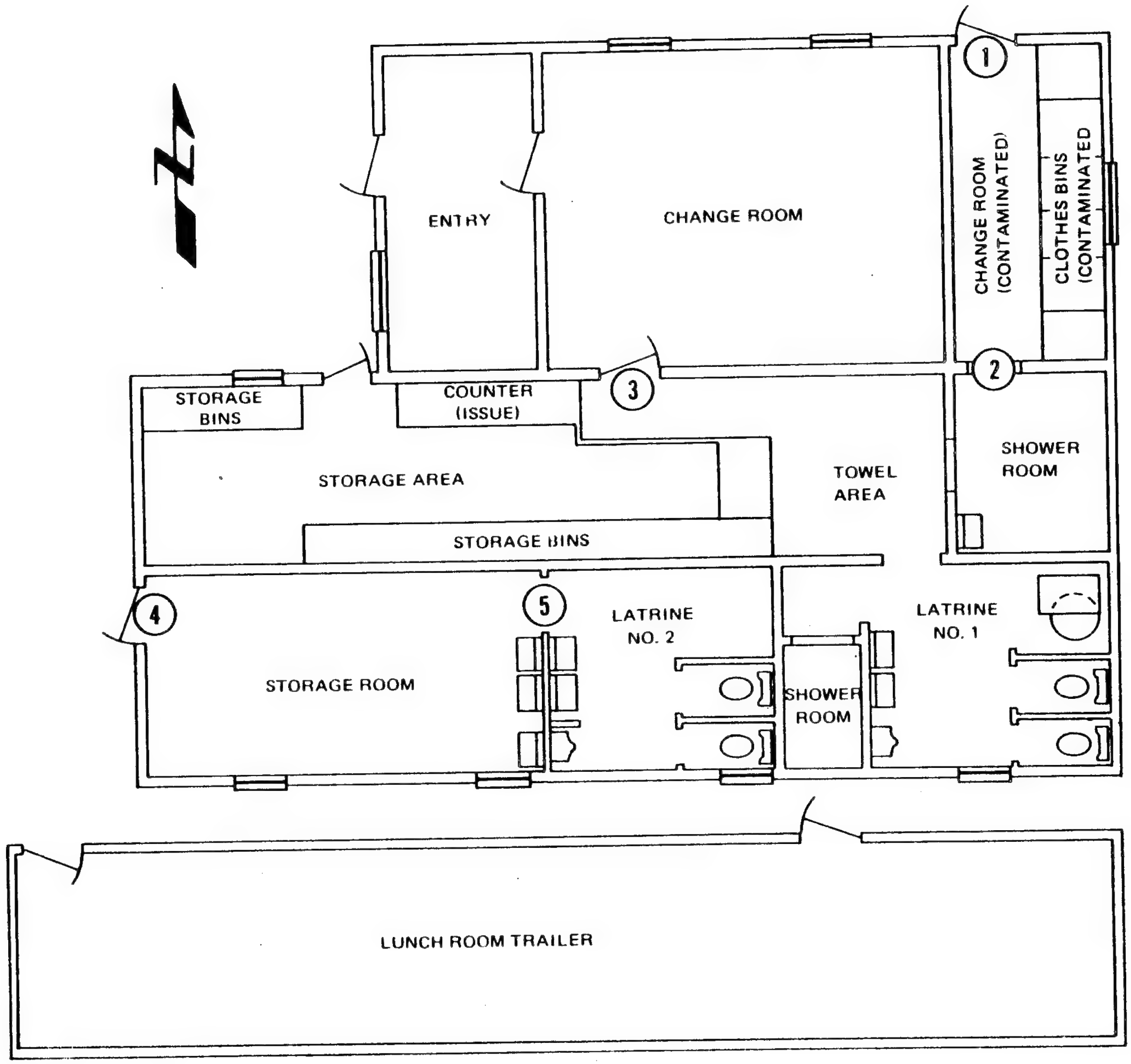


FIGURE B–3. LUNCH, BREAK AND EMERGENCY CHANGE AREA - BUILDING 527

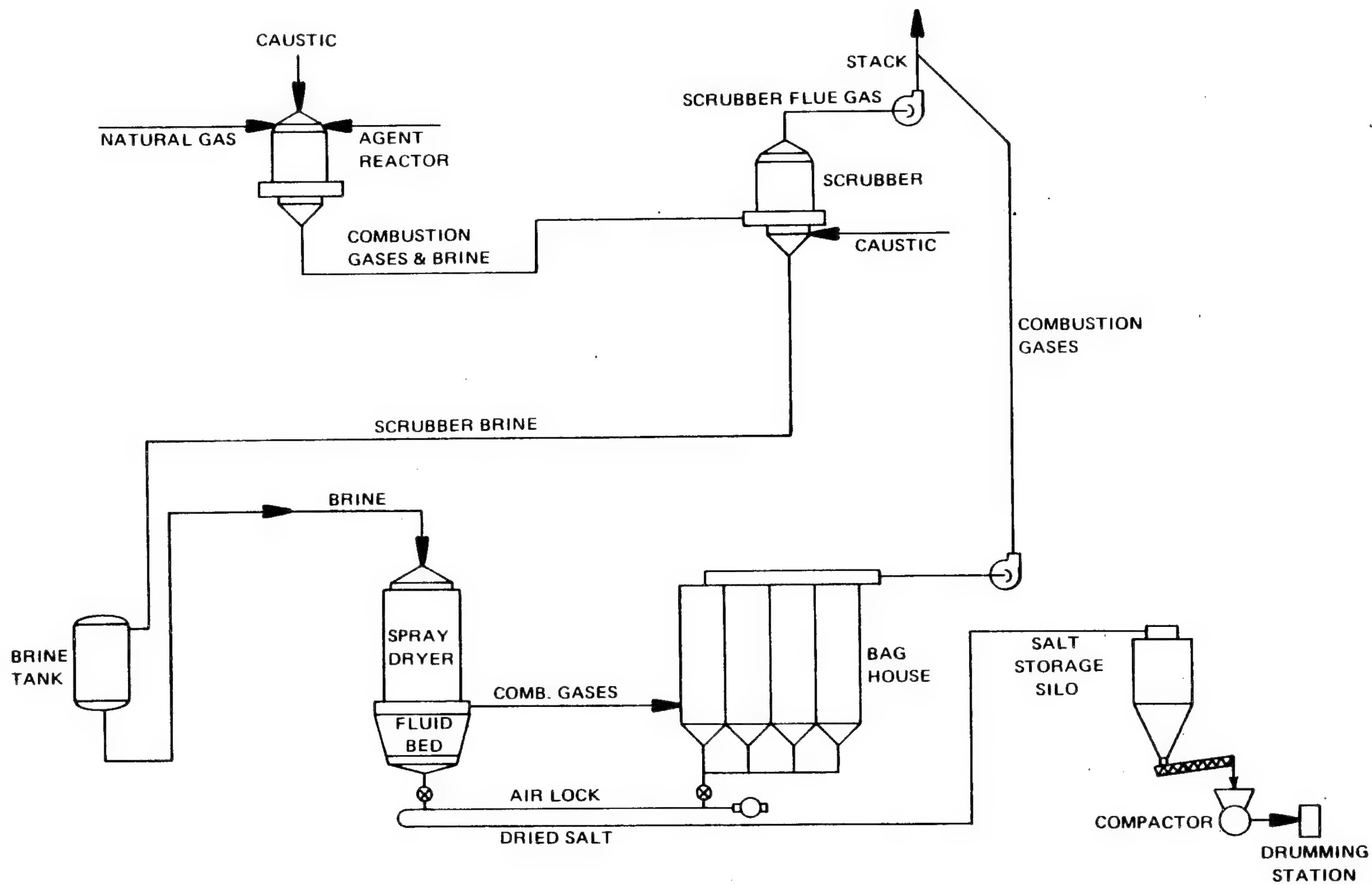


FIGURE B–4 THE TAILOR MUSTARD INCINERATION SYSTEM

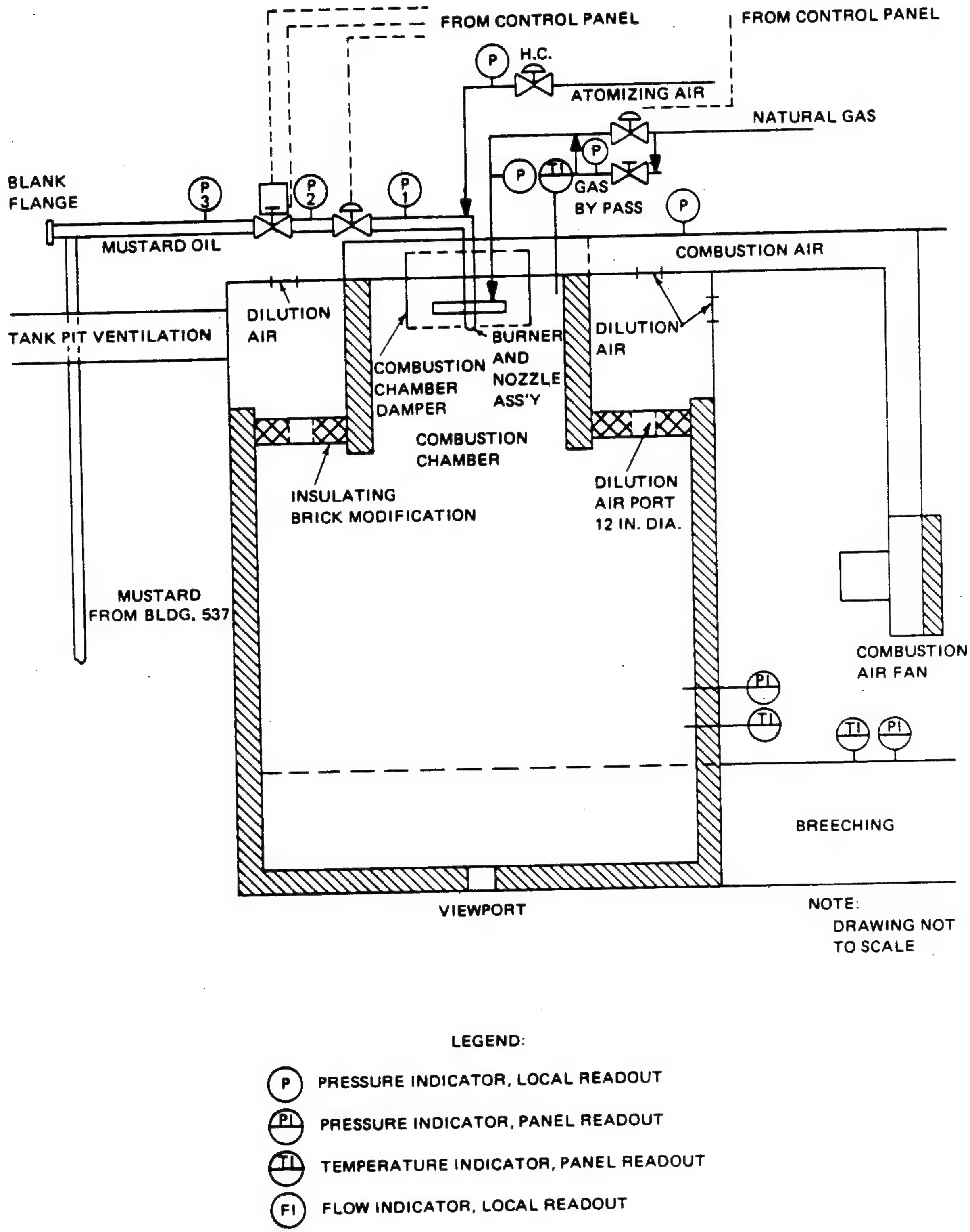
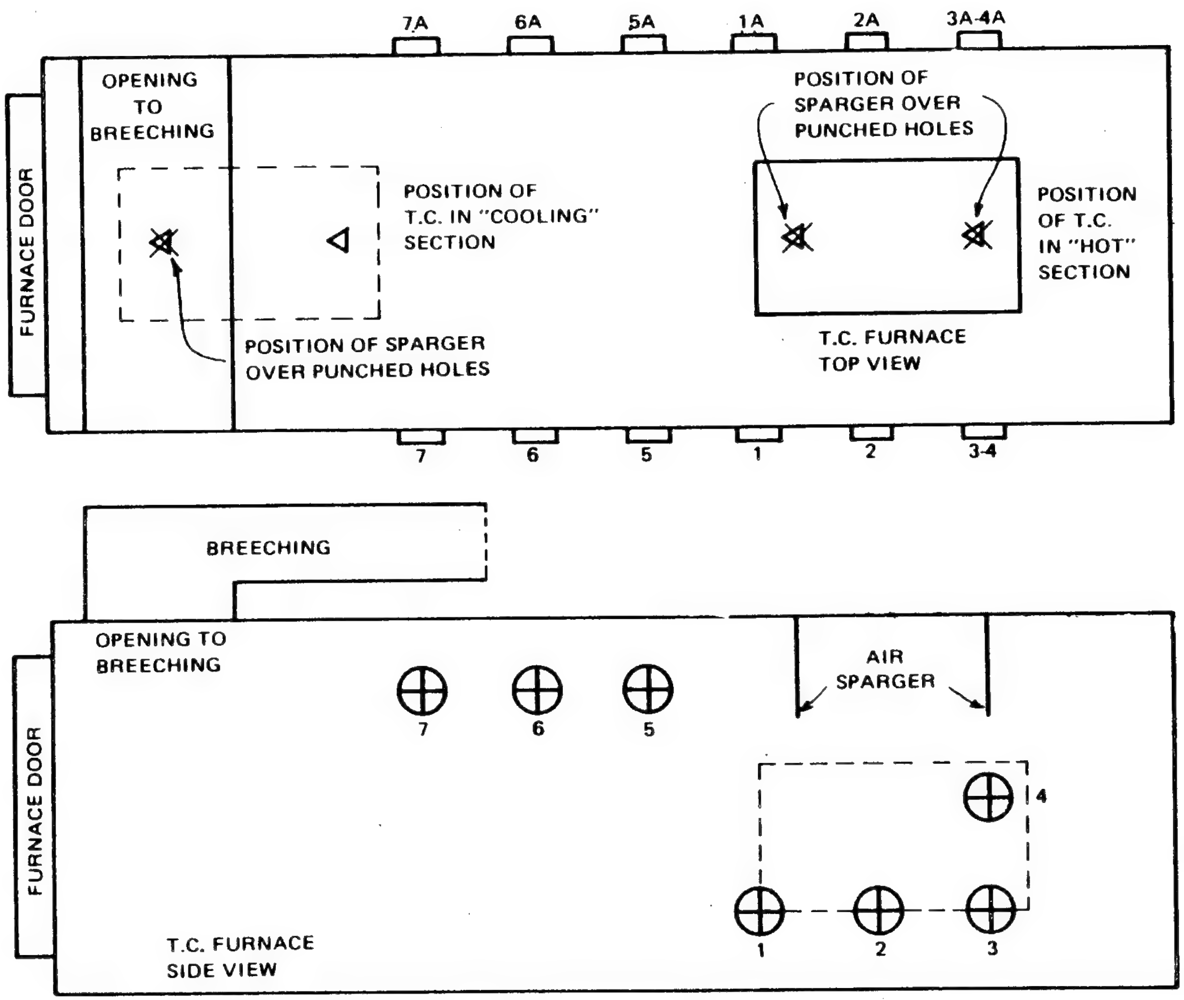


FIGURE B–5. BULK INCINERATOR FURNACE



NOTE
BURNERS 4, 4A
5, 5A
6, 6A
ARE NOT LOCATED IN THE WEST FURNACE
BURNERS 7 AND 7A ARE REFERRED TO AS "AFTER BURNERS"
DRAWING TO APPROX. SCALE ONLY
REFER TO TECHNICAL DATA PACKAGE FOR FURNACE SPECIFIC DIMENSIONS

FIGURE B–6 TON CONTAINER FURNACE BURNER LOCATIONS

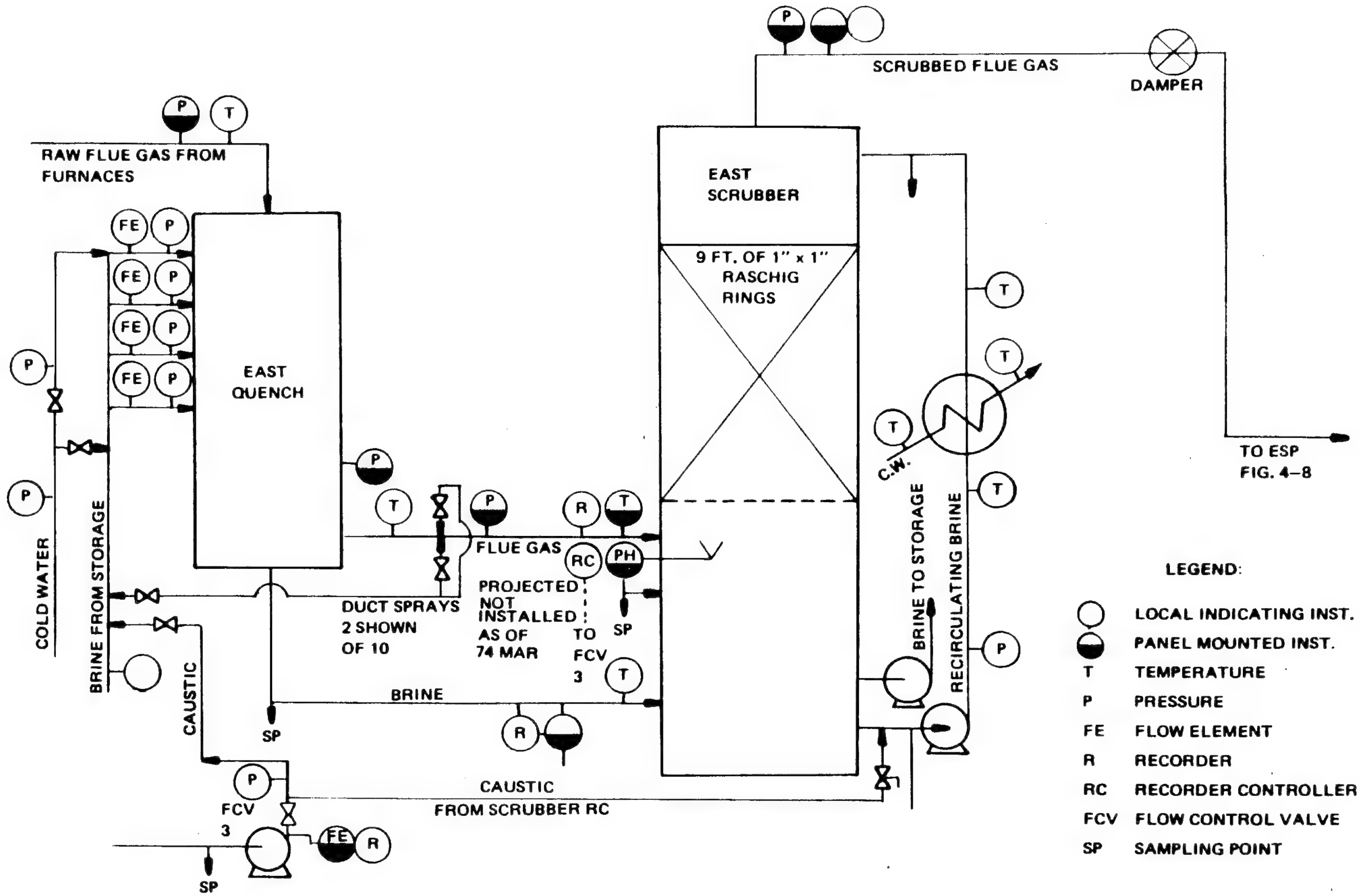


FIGURE B–7 EAST QUENCH/SCRUBBER SYSTEM INSTRUMENTATION

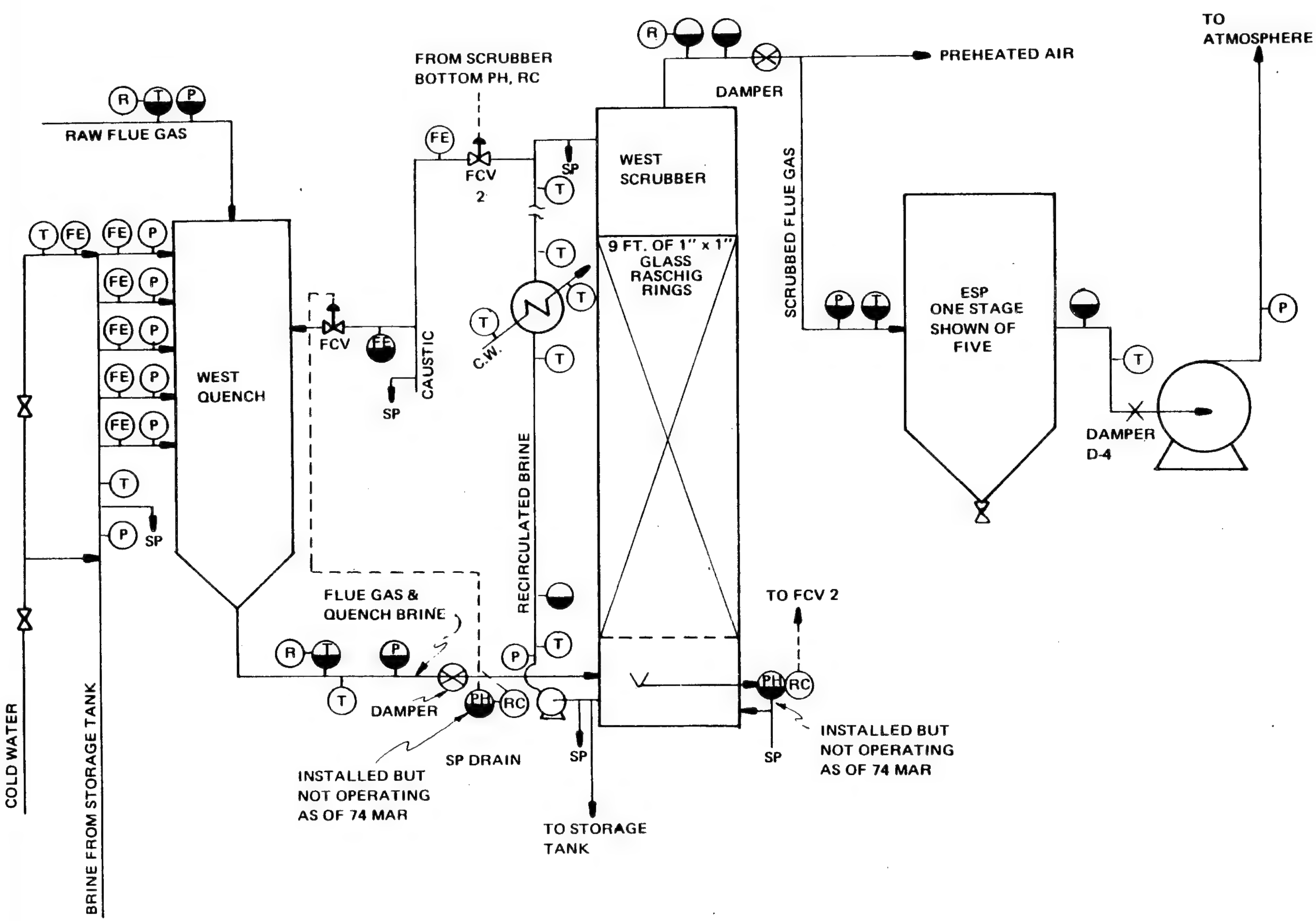


FIGURE B–8 WEST QUENCH/SCRUBBER AND ESP INSTRUMENTATION

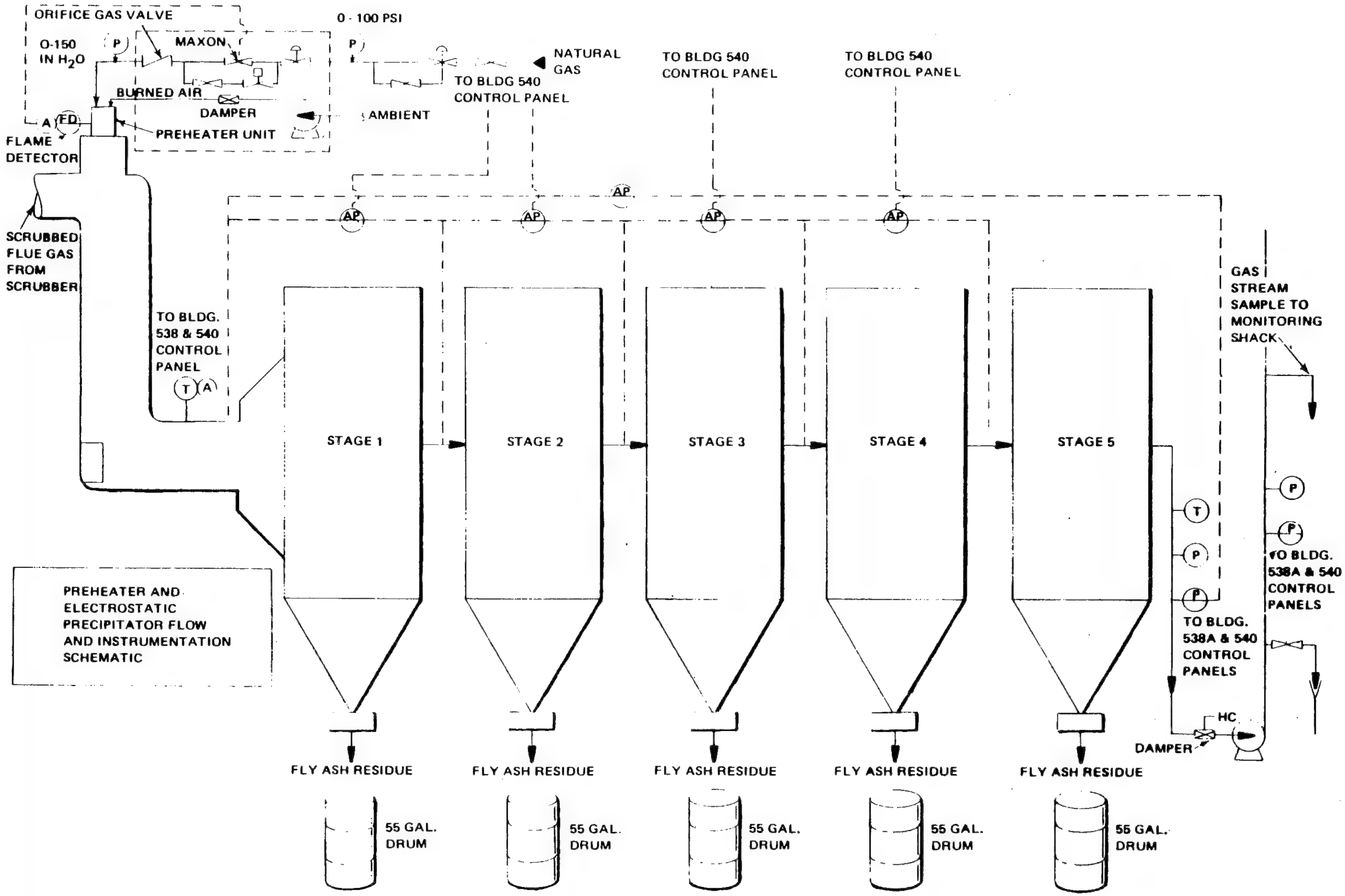
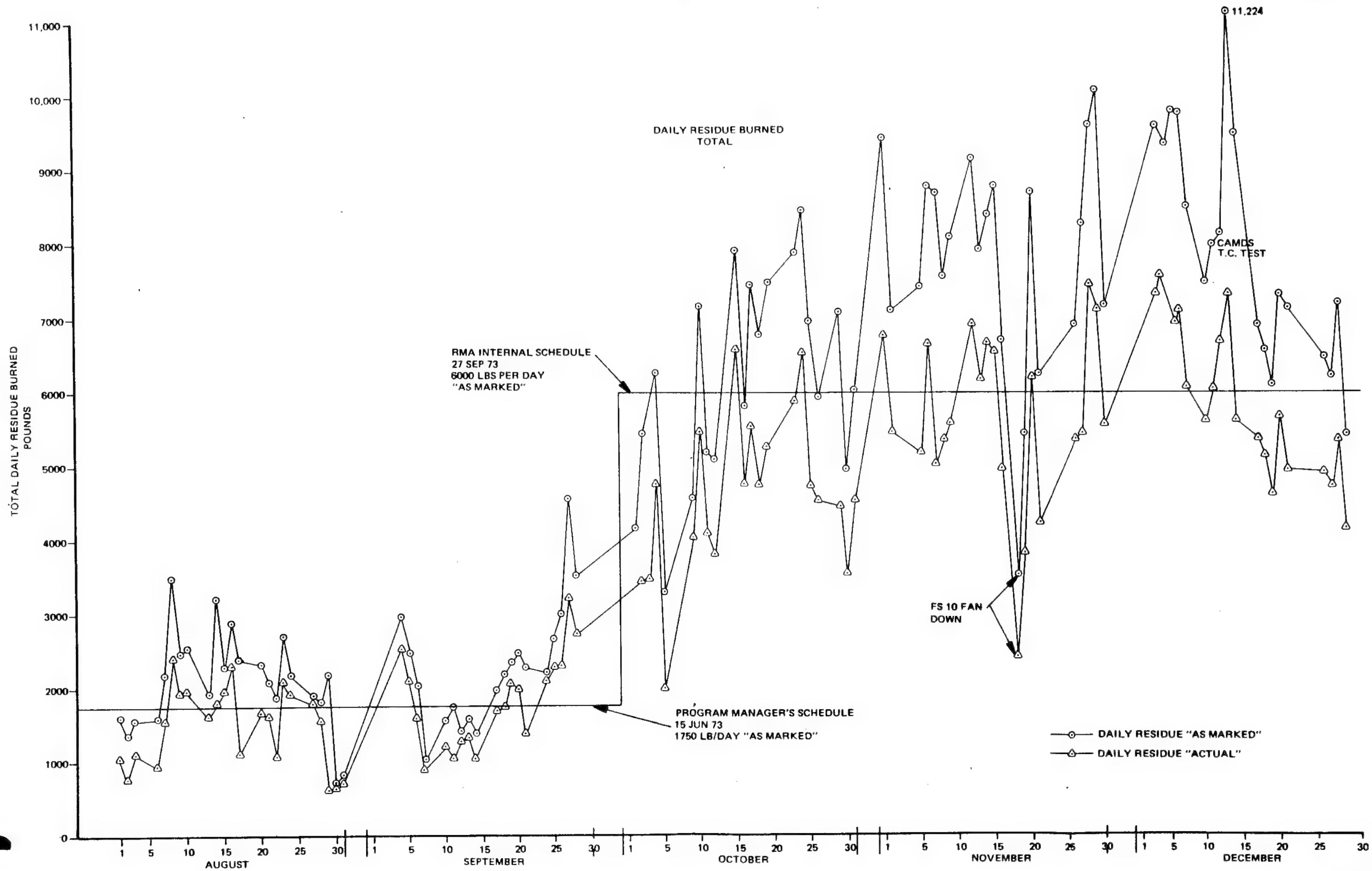
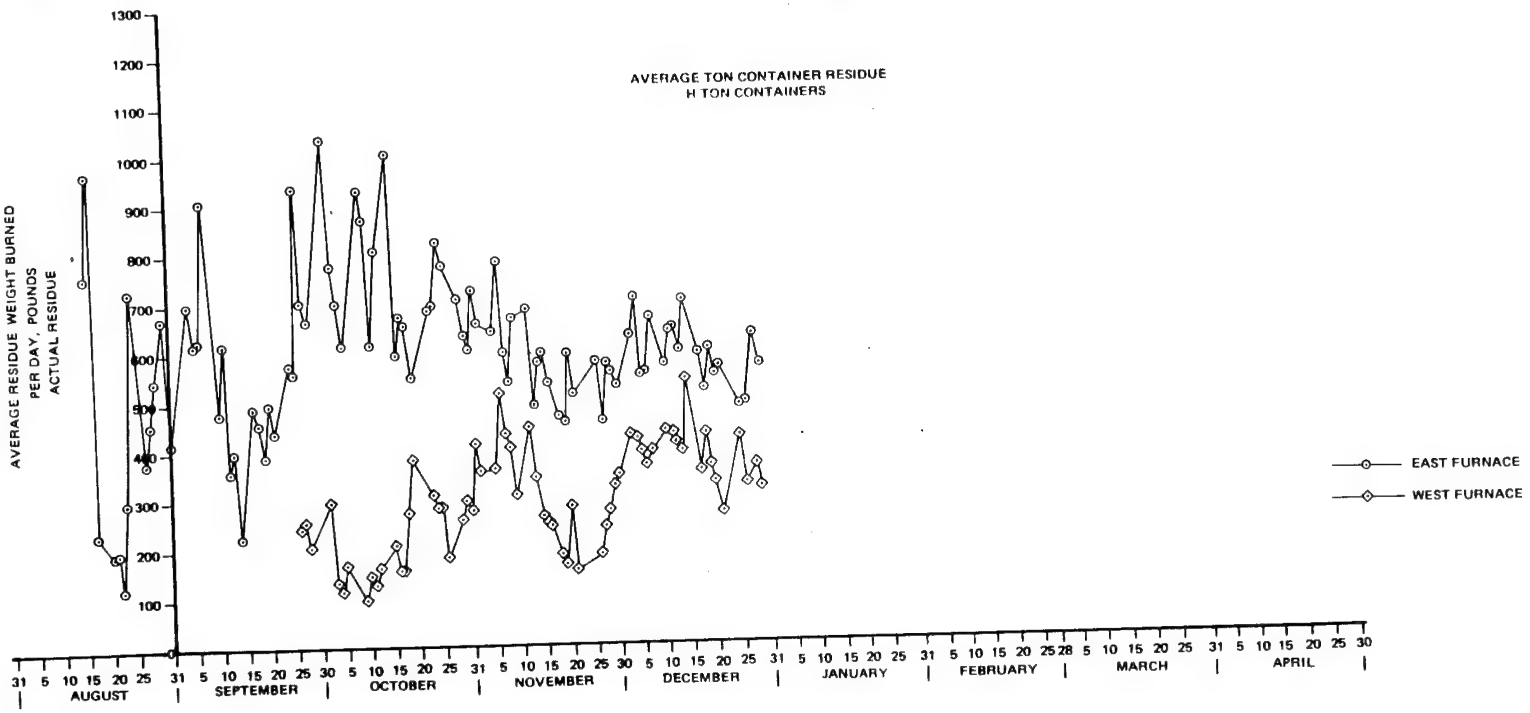
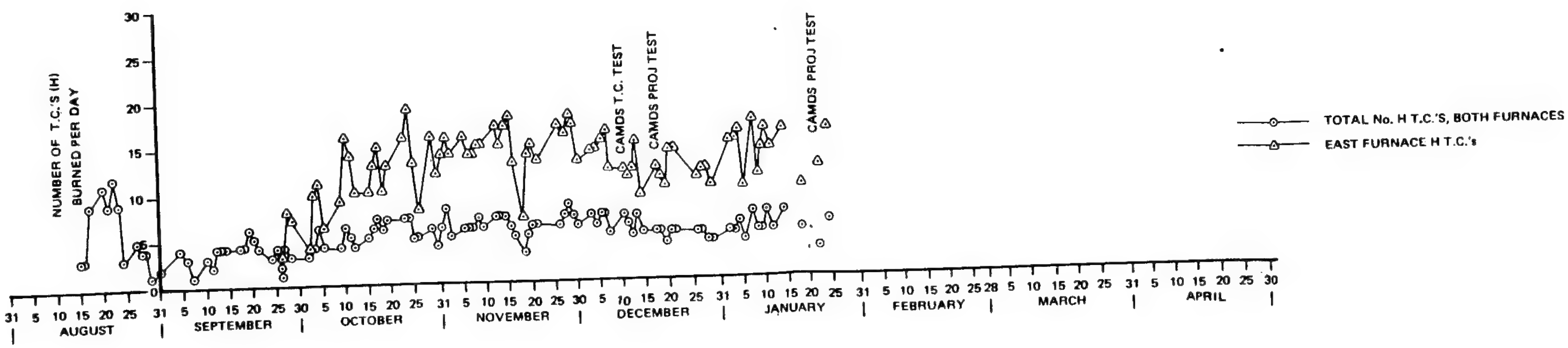


FIGURE B–9 ESP


DAILY RESIDUE BURNED
TOTAL
TOTAL DAILY RESIDUE BURNED
POUNDS
11,224
CAMDS
T.C. TEST
RMA INTERNAL SCHEDULE
27 SEP 73
6000 LBS PER DAY
"AS MARKED"
PROGRAM MANAGER'S SCHEDULE
15 JUN 73
1750 LB/DAY "AS MARKED"
FS 10 FAN
DOWN
DAILY RESIDUE "AS MARKED"
DAILY RESIDUE "ACTUAL"
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

ITEM 7 & 8


AVERAGE TON CONTAINER RESIDUE
H TON CONTAINERS
AVERAGE RESIDUE WEIGHT BURNED
PER DAY, POUNDS
ACTUAL RESIDUE
EAST FURNACE
WEST FURNACE
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL


NUMBER OF T.C.'S (H)
BURNED PER DAY
CAMDS T.C. TEST
CAMDS PROJ TEST
CAMDS PROJ TEST
TOTAL No. H T.C.'S, BOTH FURNACES
EAST FURNACE H T.C.'s
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL

ITEM 5 & 6

DATE: ____________________

TIME	PRESSURE					QUENCH RINGS										COLD WATER		CAUSTIC				TEMP				HEAT EXCHANGER				PUMP PRESSURE		
	QUENCH TOWER INLET	QUENCH DUCT	SCRUBBER TOWER OUTLET	PRECIPITATOR OUTLET	STACK	1		2		3		4		5		6		QUENCH DUCT pH		QUENCH TOWER FLOW	SCRUBBER TOWER FLOW	QUENCH		SCRUBBER		BRINE		COLD WATER		RECIR PUMP PRES	DISCH PUMP PRES	QUENCH BRINE PUMP PRES
						FLOW	PRES	FLOW	PRES	FLOW	PRES	FLOW	PRES	FLOW	PRES	FLOW	PRES					IN	OUT	IN	OUT	IN	OUT	IN	OUT			

ITEM 21 QUENCH SCRUBBER NO. 12

EAST SCRUBBER/PRECIPITATOR

DATE: ______________

SHIFT: ______________

SUPERVISOR: ______________

TIME	SCRUBBER GAS				BRINE			HEAT EXCHANGER TEMPS				ELECTROSTATIC PRECIPITATOR								
								BRINE		WATER						PRESSURE DROPS				
	TEMP IN	TEMP OUT	PRESS IN	PRESS OUT	pH	SP.GR.	RECIRC PUMP PRESS	IN	OUT	IN	OUT	TEMP IN	TEMP OUT	PRESS IN	PRESS OUT	1	2	3	4	5

ITEM 20

EAST FLUE GAS QUENCH

DATE: ____________

SHIFT: ____________

SUPERVISOR: ____________

TIME	GAS			CAUSTIC		BRINE					QUENCH SPRAYS									
											PRESSURES					FLOWS				
	TEMP IN	PRESS IN	QUENCH PRESS	LEVEL	FLOW	pH	LEVEL 536	LEVEL 538	PUMP PRESS	TEMP TO SCBR	TOP	2ND	3RD	BOT'M	DUCT	TOP	2ND	3RD	BOT'M	DUCT

ITEM 19

HYDRAZINE FURNACE

DATE: ____________

SHIFT: ____________

SUPERVISOR: ____________

TIME	PERCENT OPENING			FURNACE ΔP	TEMPERATURES			PRESSURES							GALLONS MUSTARD BURNED	TOTAL
	AIR DAMPER	NAT. GAS VALVE	MUSTARD VALVE		STACK	COMB. CHAMBER	FURNACE	COMB. AIR	ATOM. AIR	NAT. GAS	MUSTARD NO. 1	MUSTARD NO. 2	MUSTARD NO. 3			

ITEM 18

TON CONTAINER DECONTAMINATION

DATE: ____________

SHIFT: ____________

SUPERVISOR: ____________

FURNACE	T.C. SERIAL NO.	MATERIAL	MARKED RESIDUE WEIGHT	GR.WT. BEFORE BURNING	GR.WT. AFTER BURNING	WEIGHT BURNED	ENTRY TIME	ENTRY TEMP	PEAK TEMP	TIME INTO COOLING	TEMP INTO COOLING	EXIT TIME	TOTAL FURNACE TIME		

ITEM 8

DATE: ____________________

SHIFT: ____________________

SUPERVISOR: ____________________

NO.	T.C. SER. NO.	LOT NO.	FILL DATE	MAT'L	SKIN TEMP.	GR.WT. BEFORE TRANSFER	GR.WT. AFTER TRANSFER	WT. MUSTARD TRANSFER	STENCIL WEIGHT MUSTARD IN T.C.	WEIGHT RESIDUE IN T.C.	STORAGE TANK USED	UNLOAD CUBICLE USED	MUSTARD STORAGE TANK READINGS					
													TIME	TANK	MEASURE	GALLONS	GALLONS USED	TOTAL
1																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		

ITEM 4

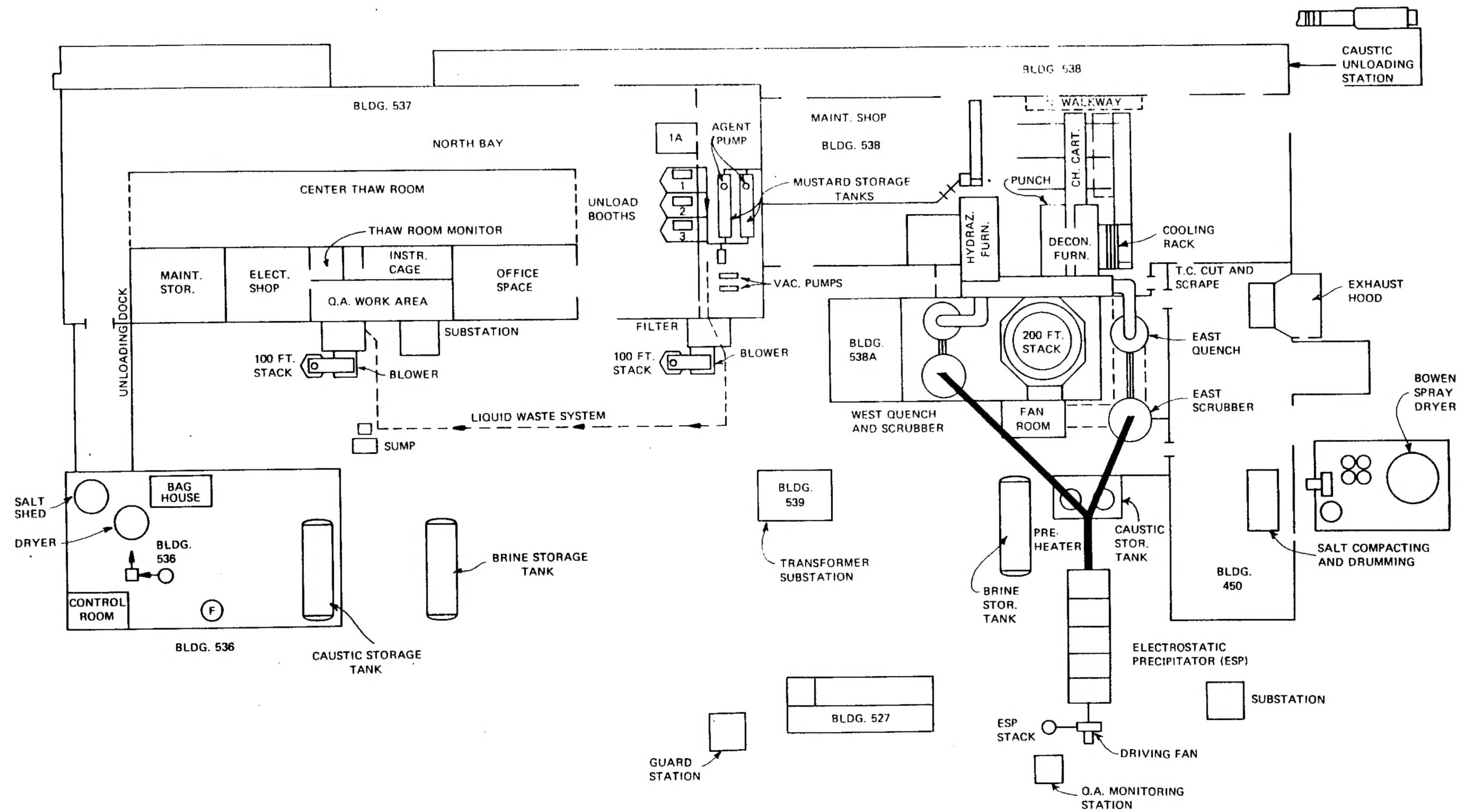


FIGURE B–2 PLANT LAYOUT - MUSTARD DISPOSAL FACILITY, ROCKY MOUNTAIN ARSENAL - AS OF 1 NOV., 1973